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AIRCRAFT

MiG – 21F – 13

TECHNICAL DESCRIPTION

VOLUME IV

SPECIAL EQUIPMENT

GROUP 1
Excluded from automatic downgrading and declassification

2

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A I R C R A F T

MIG - 21F - 13

TECHNICAL DESCRIPTION

VOLUME IV

SPECIAL EQUIPMENT

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Figure 1. The MiG-21F-13 Aircraft
(Front View)

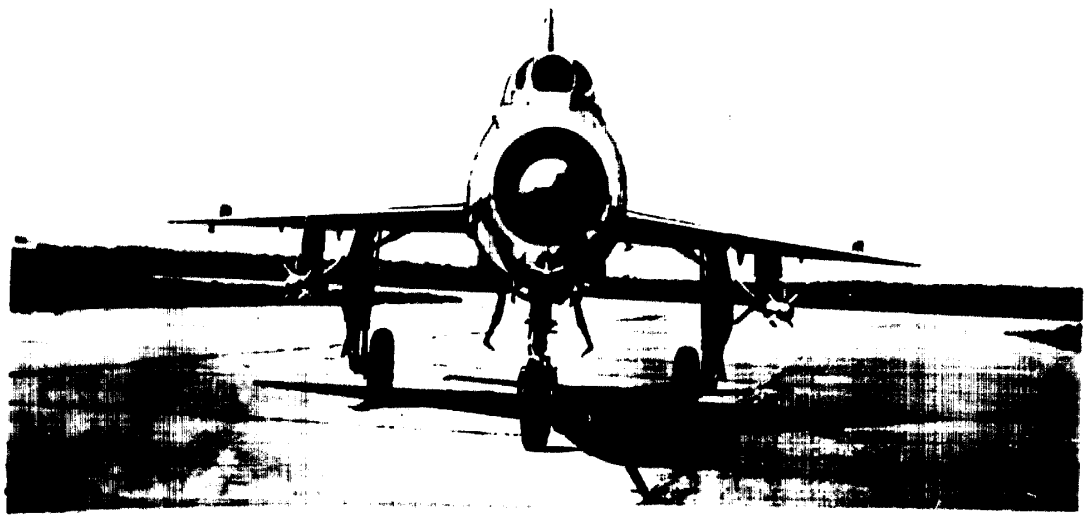

Рис. 1. Самолет МиГ-[illegible]

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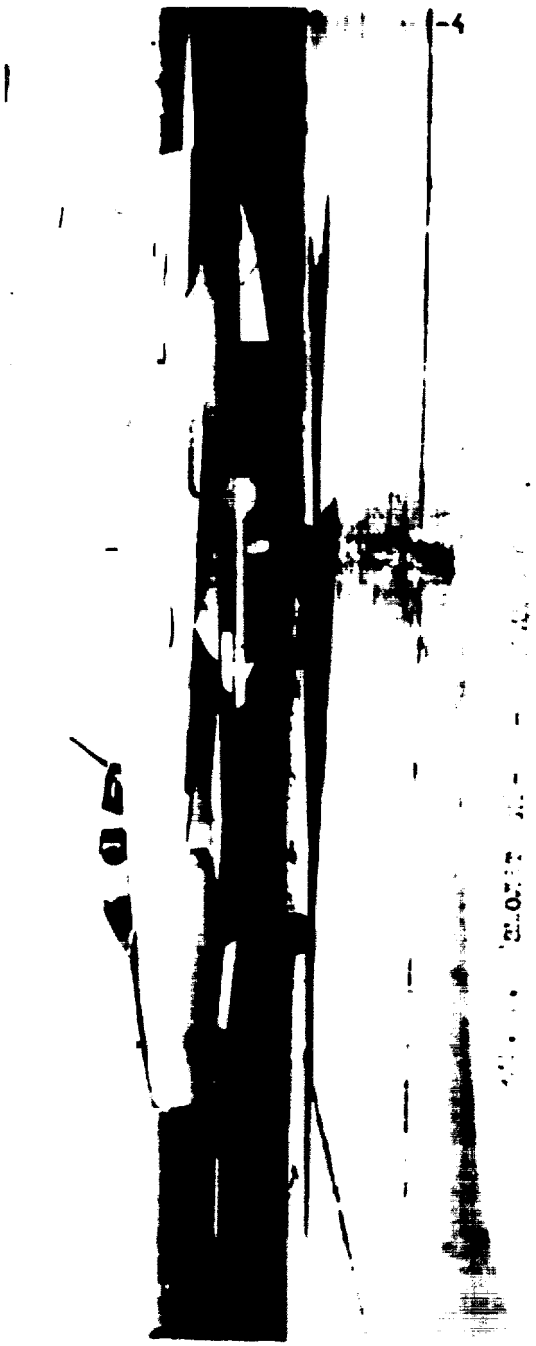

Figure 2. The MiG-21F-13 Aircraft (Side View)

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The MiG-21F-13

Aircraft

Technical Description

Book IV

Special Equipment

Page 4

Introduction

The MiG-21F-13 aircraft is equipped with modern instruments and radio equipment, making it possible for the aircraft to carry out its mission in all kinds of weather, day or night.

The compact positioning of the instruments in the cockpit provides sufficient convenience for pilot operation. Control of the electrical aggregates, of the instruments, and of the radio equipment, is, in the main, by remote means.

All of the aircraft's special equipment has been divided into groups as follows:

electrical equipment;

radio equipment;

instrumentation;

oxygen equipment;

photographic equipment.

Each of these groups carries out a definite, independent function; but at the same time, each group is closely connected with the others.

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The aircraft's electrical equipment consists of the power source, the equipment using the power, and the electrical network.

The electrical equipment serves to ensure operation and checking of the operation of various of the aircraft's systems and aggregates.

The aircraft's radio equipment includes the radios used for communications, the blind landing equipment, including the automatic radio compass, the

receiver marker installation and the radio altimeter, the responder in the recognition radar system, and the range-only radar, which functions in conjunction with the aerial gunnery sight.

The radio equipment provides the means for solving various of the problems concerned with radio communications, recognition, signaling, piloting, navigation, etc.

The aircraft's instrumentation includes the piloting and navigating instruments, the instruments for checking the power plant, and the instruments for checking the operation of the individual aggregates and systems.

The installed instrumentation permits flying day or night, in all kinds of weather at any altitude up to service ceiling; ensures orientation in space and along the course; and provides the means for checking the operation of the power plant and other aircraft systems. The instrumentation ensures correct use of the flight and tactical capabilities of the aircraft.

The aircraft's oxygen equipment consists of the KKO-3 outfit with oxygen excess pressure in the hermetically sealed helmet and in the pneumatic system for the pressure equalizing flight suit, regulated automatically according to flight altitude.

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The oxygen equipment serves to provide the necessary environment for

the pilot and safeguards his capacity to function both while at high altitudes and when being ejected.

The photographic equipment in the aircraft consists of the AFA-39 aerial camera and the SSh-45-I-100-OS gamera gun.

The AFA-39 aerial camera is designed for carrying out aerial reconnaissance.

The SSh-45-I-100-OS aerial camera gun is designed to check sighting accuracy. Materials on the SSh-45-I-100-OS are contained in Book II, "Armament," which gives the technical description.

The book on technical description consists of five chapters, in the following sequence:

Chapter 1 - Electrical Equipment

Chapter 2 - Radio Equipment

Chapter 3 - Instrumentation

Chapter 4 - Oxygen Equipment

Chapter 5 - Photographic Equipment

The book contains information needed to master and operate the aircraft, in so far as the special equipment is concerned, and it also provides instructions for the installation and the removal of the most important of the equipment aggregates.

Information on the aggregates manufactured by specialized enterprises is presented in brief in order that the reader can become acquainted with them. Detailed information on the design and the operation of these aggregates must be obtained from the descriptions and instructions provided for them by the manufacturer.

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The main feeder circuits, as well as circuits which are grouped in the aircraft are added to the book in the form of an appendix (in a separate portfolio) for convenience in handling.

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Chapter I

Electrical Equipment

1. General Information

The electrical equipment in the aircraft is an assembly of electrical devices, connected in groups by type of function and interconnected by electric cables. These groupings form the various electrical systems in the aircraft.

The aircraft's electrical equipment consists of the power source, the equipment using the power, and the electrical network. It includes the protective devices, switching apparatus, electric wiring and electrical connectors.

The chief source of electric power is the starter-generator, type GSR-ST-12000VT, connected to the electrical network installed in the aircraft. The GSR-ST-12000VT is driven by the aircraft power plant and is the source of supply after the engine is started.

When the aircraft is on the ground the power supply is provided from the airfield when it is time to start the engine. At this time the starter-generator is a power consumer.

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Two storage batteries, type 15-STsS-45, serve as reserve power sources for the aircraft.

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The storage batteries are used primarily for starting the engine in the air and on the ground in other than airfield conditions.

The aircraft's internal electrical network is a single-wire circuit in which the aircraft hull is the common negative for all the electrical devices. The 27 volts, ±10%, from the sources of supply is fed to the consuming devices by a cable which is insulated from the airframe.

The aircraft has a special receptacle to take the airfield power supply [illegible].

Inverters, types PO-750A, PO-500A, and PT-500Ts, supply 115 volts, 400 cycles, and 36 volts, 400 cycles, alternating current. They, at the same time, take 27 volts direct current.

Voltage from the sources is fed to the equipment requiring it.

Using electrical energy in the aircraft are;

Engine starting and running aggregates;

The radio and radar installations;

The aggregates in the cannon and rocket installations;

The ASP-5ND air gunnery sight, and the SIV-52 infrared viewfinder.

Figure 3. Schematic diagram of electric power distribution to consuming devices

Fuel system aggregates;

Aggregates for regulation cockpit air temperature;

Aggregates for the fire protection equipment;

Heaters for clocks, pilot tube and storage batteries;

Signal and lighting apparatus;

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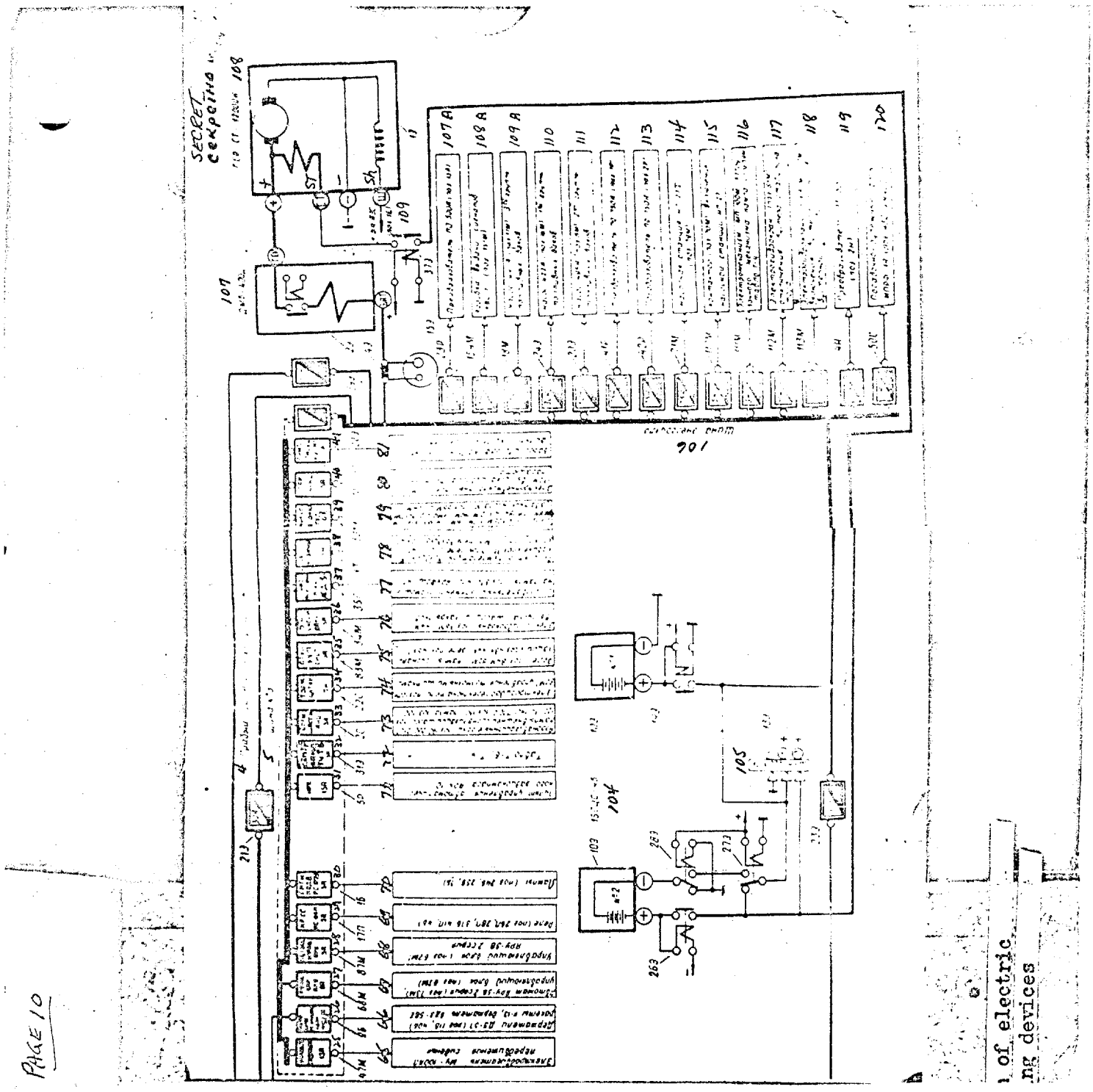

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[Append page 9b here]

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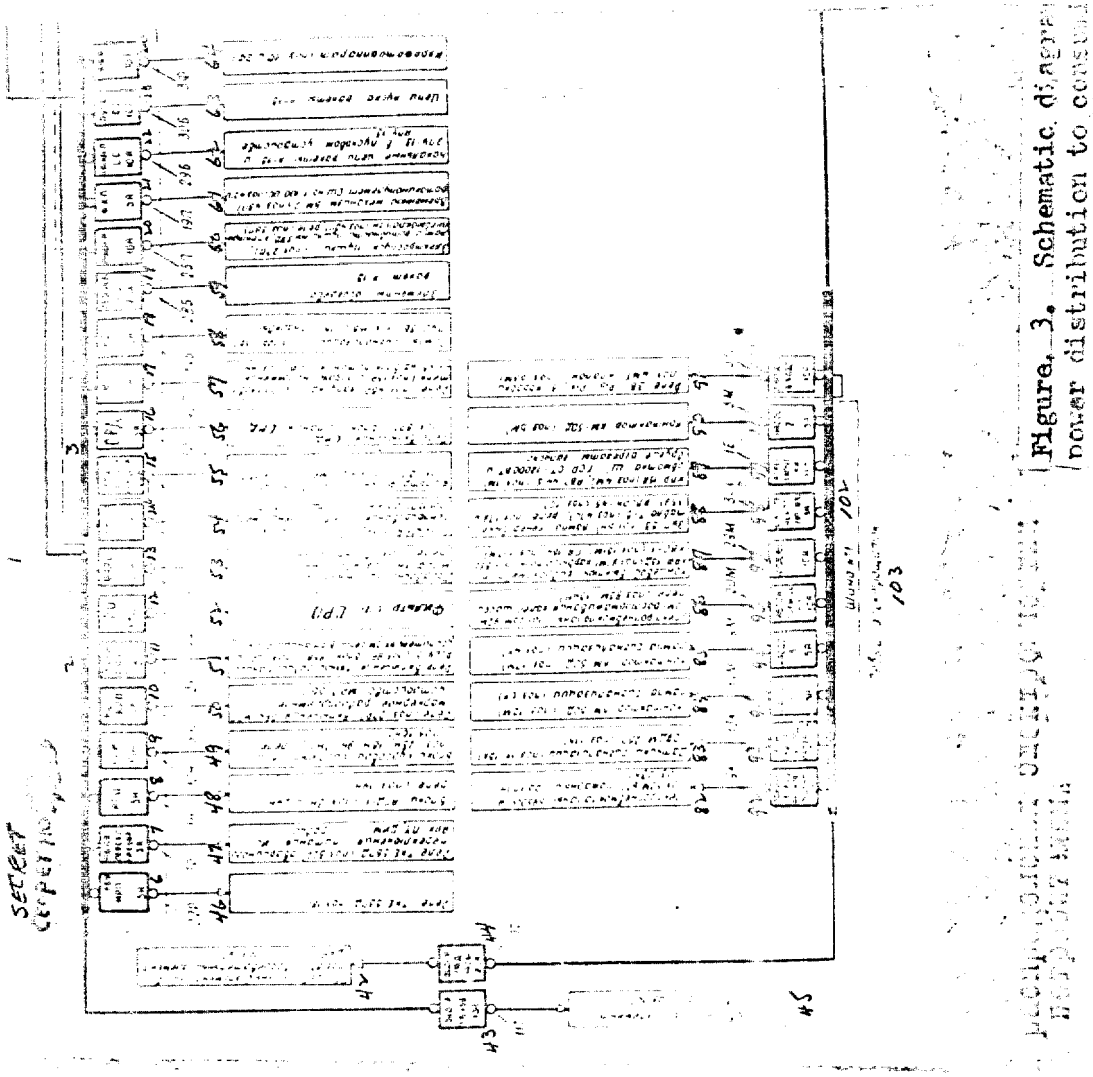

Figure 3. Schematic diagram of power distribution to consul

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piloting and navigation instruments;

instruments for checking engine operation;

pump station and electrical mechanism for trim effect;

aggregates in the hydraulic system, the air system, landing gear, wheel brakes, and others.

The bus bar of the power supply unit, connected to the starter-generator, to the storage batteries, and to the receptacle taking the airfield power supply, is used to distribute electric power. Figure 3 shows the devices using electricity.

The power supply unit (Figure 4) furnishes power directly for certain uses and is connected to:

(TEXT CONTINUES IMMEDIATELY FOLLOWING LEGEND FOR FIGURE 3)

Figure 3. Legend

1. Starboard forward switchboard
2. Bus bar number 2
3. Bus bar number 4
4. Starboard after switchboard
5. Bus bar number 3
6. RVU MRP 5A (22R)
7. Emergency transfer switch for converter 5A (7R)
8. AGD 5A (1N)
9. KSI 10A (10N)
10. RVU MRP 5A (34R)
11. Radio oil pressure 5A (3R)
12. SRO 10A (49R)
13. Floodlights 25A (41S)
14. Sight 10A (2P)
15. Sight, Sight heater 20A (1P)
16. SRD 5A (6R)
17. SIV-52 5A (46P)
18. RS 10A (14B)
19. SS heaters 20A (28B)
20. Cannon 10A (25P)
21. FKP 5A (19P)
22. SS Silament 10A (29B)
23. SS launch 10A (30B)
24. AFR 10A (3F)
25. (blurred) 13A (47M)

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26. (blurred) (9B)
27. (blurred) (68M)
28. (blurred) 5A (87M)
29. IR, SS, RS (blur) 5A (17P)
30. Signal suspension RS APU 5A (1B)
31. MRK 15A (5R)
32. (blurred) 5A (31E)
33. (blurred) 5A (2S)
34. (blurred) panel 5A (22S)
35. (blur) booster system 5A (83M)
36. UPR landing gear (blur) 5A (34M)
37. UFO (blurred) (35S)
38. (blurred) 5A (1T)
39. Cone interlock (blur) 10A (33M)
40. 10RM parachute 5A (46M)
41. Recorder (blur) (37K)
42. Heater elements for clocks (sym. 8T), heater element DUAS (sym. 9T)
43. Heater TP156 10A (11T)
44. Clock heaters 20A (7T)
45. Heater element TP-156 (sym. 10T)
46. Relay TKYe-53PD (sym. 18R)
47. Relay TKYe-56PD (sym. 32 R) for emergency transfer switch supplying IS, ARK, PT, DIM, radio
48. AGD-1 blocks (sym. 3N and 24N), relay (sym. 19N)
49. KSI course system blocks (sym. 25N, 18N, 9N, and 7N), relay (sym. 16N)
50. Relay (sym. 27R). RVU, MRP, MRP-56P marker radio receiver installation connections
51. Relay for connecting RSIU-5 (sym. 9R) communications radio set, ABV block (sym. 10R), and amplifier UD-2M series 5 for RSIU set
52. Filter from SRO
53. MPRF-1A landing and taxying lights (sym. 43S and 44S), relays (sym. 15S, 48S and 49S)
54. ASP-5ND block No 1 (sym. 12P), damping push button (sym. 8P), potentiometer (sym. 15P), ASP-5ND block No 7 (sym. 16P) (TN: Block No could be "2")
55. F-14A filter (sym. 4P), block No 1 (sym 12P), potentiometer (sym. 15P)
56. Relay for connecting SRD (sym. 8R), SRD supply block
57. Relay (sym. 48R) for triggering converter (sym. 15R) and delivery of 115 volts AC to SIV (sym. 44P) supply block
58. Indicator lights (sym. 12B, 13B), PUS-36 (sym. 16B, 17B), projectiles
59. K-13 missile heater elements
60. Electrical firing for cannon (sym. 27P), cannon readiness light (sym. 37P), electropneumatic valve (sym. 40P), relay (sym. 38P)
61. VM-2 timing mechanism (sym. 43P), SSh-45-i-100-0S (sym. 42P) camera gun
62. Filament circuits for K-13 and EPU-13 in APU-13 launching system
63. Launch circuits, K-13
64. Aerial photographic equipment (sym. 1F and 2F)
65. MU-100AP electric motor for moving seat
66. DE-57 (sym. 11B, 40B) racks for K-13 missile, 5DE-56Ye rack
67. ARU-3V, series 2 automatic device (sym. 73M), control block (sym. 52M)
68. ARU-3V, series 2 control block (sym. 52M)
69. Relay (sym. 26P, 28P, 37B, 41P, 4B)

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70. Lamps (sym. 24B, 25B, 7B)
71. Control panel, ARK-10 automatic radio compass
72. Display T-6, T-4
73. Air navigation lights (sym. 19S, 20S, 21S), lights for external landing gear indication (sym. 12S, 13S, 14S), PPS-2 (sym. 11S), lamp (sym. 10S)
74. Electro-hydraulic transfer switches (sym. 122M, 32 M) for speed brake control
75. Relays (sym. 84M, 85M), indicator lights (sym. 43K, 44K), relay (sym. 45K)
76. Electro-hydraulic valves (sym. 36M, 44M) for lowering landing gear and flaps
77. Heater element for sealed helmet, lamps (sym. 37S, 40S), ARUFOSh-45
78. Cockpit air temperature regulator (sym. 3T), relay block (sym. 14T), electrical air control (sym. 4T)
79. (blurred)
80. Electro-pneumatic valves (sym. 130M, 132M) for streaming and jettisoning drag chute
81. K2-717A (sym. 39K) barometric speed indicator (barospidograf), K2-717A (sym. 38K) filter
82. Electro-pneumatic valves 695000/A (sym. 52M, 6T), fire extinguisher (sym. 23K)
83. Indicator transmitters (sym. 1K, 15K), 2EDM-250 (sym. 11K)
84. KM-50D (sym. 12M) contactor, indicator light (sym. 6K)
85. KM-50D (sym. 17M) contactor, indicator light (sym. 7K)
86. Electro-pneumatic valves (sym. 23M, 92M, 22M) for releasing the landing gear wheel brakes, relay (sym. 93M, 134M)
87. Terminal switches for KAF-13D (sym. 97M) hydraulic decelerator, carburetor (sym. 5Ye), KVC-1 (sym. 151M), GA-164 (sym. 153M)
88. KUP-53 (sym. 6N), "generator off" indicator light T-6 display (sym. 47S), relay (sym. 11E and 33E), KLSRK-45 (sym. 1S)
89. KPR-15A (Sym. 4M), AV7-44-5 (sym. 1M), winding "Sh" GSR-ST-12000VT and other start aggregates
90. KM-50D contactor (sym. 6M)
91. Relays 3V, R_{10}, R_{13}, 3 of box (sym. 4M), valve (sym. 63M)
92. Fire extinguishing equipment, deicer 5A (9K)
93. EDM Hydraulic indicator (blur) 5A (13K)
94. Pump No 1 5A (14M)
95. Pump No 3 5A (9M)
96. Automatic wheel braking 10A (20M)
97. Afterburner 10A (29M)
98. (obliterated) 5A (34K)
99. Start aggregates 25A (1 Ye)
100. Pump No 2 5A (5M)
101. Start (blur) 10A (31Ye)
102. Bus bar number 1
103. Port switchboard
104. 15STsS-45
105. ShRA-250MLK
106. Power unit bus bar
107. DMR-400D

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108. GSR-ST-12000VT
109. From AES (sym. 1Ye)
107A. PO-500A (sym. 15R) converter
108A. Box for delivery of signals KVS-1 (sym. 151M)
109A. Pump 495A (sym. 11M) 3rd group of fuel tanks
110. Pump 422A (sym. 16M) 1st group of fuel tank
111. Pump 495A (sym. 8M) 2nd group of fuel tanks
112. PO-750A (sym. 1R) converter
113. PO-750A (sym. 2R) converter
114. Pump station NP-21T (sym. 79M)
115. Contactor (sym. 70M) for cutting in pump station NP-2T
116. Electrical mechanism MP-100M for loading mechanism for T-4 display lamp (sym. 59M)
117. Electro-hydraulic valve (sym. 81M) for cutting out stabilizer booster
118. Electro-hydraulic valves (sym. blurred) for cutting in (blur) booster (blur)
119. PT-500Ts converter (sym. 2N)
120. MPRF-1A (sym. 43S and 44S) landing and taxying lights

the pumps in the 1st, 2nd, and 3rd groups of fuel tanks;

converters PE-750A and PO-500A

pump station NP-27T;

the hydraulic and electrical valves for controlling the boosters;

the stabilizers and ailerons;

the box containing the automatic device for the afterburner, KAF-13D;

the MP-100M electrical mechanism for the trim effect loading mechanism;

the MPRF-1A floodlight;

the PT-500Ts converter.

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Figure 4. Power Supply Unit Schematic

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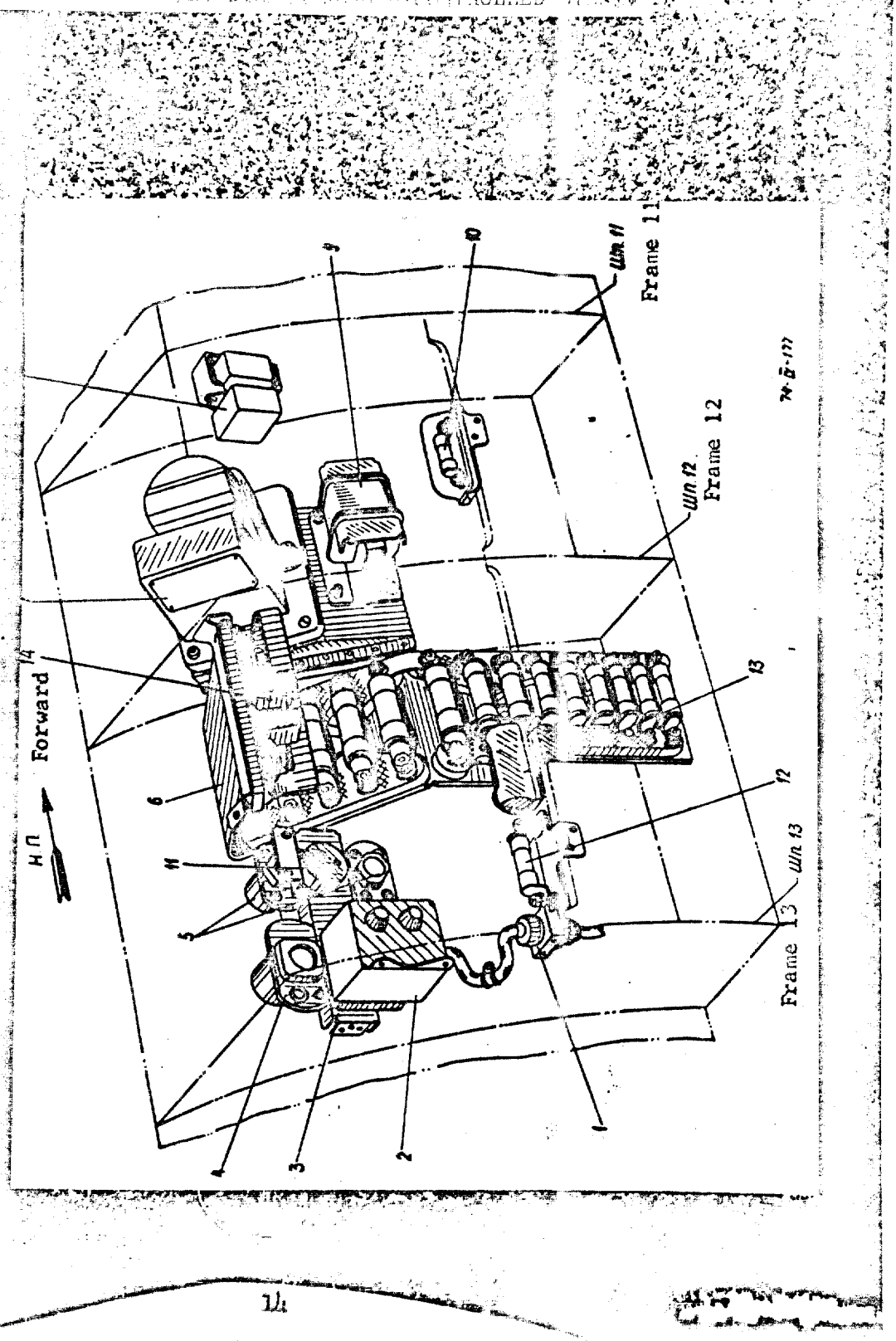

Figure 4. Power Supply Unit Schematic

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Key to Figure 4

1. Conductor connector plug from relay box
2. Relay box
3. Bracket
4. KM-100D contactor
5. KM-50D contactors
6. Panel with inertial fuses
7. DMP-400D
8. KBM-31 condenser
9. TS-9M transformer
10. IP-15 inertial fuse
11. Socket for measuring (one word blurred) from generator
12. Inertial fuse
13. Inertial fuse
14. Ammeter shunt

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The remainder of the electric power supplies the four distribution busses on the switchboards for the port and starboard consoles in the cockpit.

The starboard console has two switchboards, one forward, and one aft. Two bus bars No 2 and No 4, are installed on the forward switchboard. One bus, No 3, is installed on the after, or rear, switchboard.

The port console has one switchboard. Bus bar No 1 is installed on this switchboard.

Bus bar No 2 provides the supply for the KSI, AGI, floodlights (sym. 43S, 44S), relay (sym. 32R), the emergency converter switch (sym. 1R, 2R) and the relay (sym. 18R) for energizing the RVU and MRP in the blocks for the RSIU-5G, SRO-1 and MRP-56P and the relay (sym. 9R, 27R) for cutting in the 115 volts, 400 cycles AC for the RSIU-5G, RV-U and MRP-56P, and for the oil pressure signal.

Bus bar No.4 provides the supply to the relay (sym. 48R, 3R) for cutting in the 115 volts, 400 cycles AC, to the SIV-52 infrared viewfinder and the range-only radar, as well as to the ASP-5ND sight, the cannon, the FKP, RS, and the K-13 homing missiles ("SS").

Bus bar No 3 provides the supply to the cone and the apparatus for interlocking the throttle, controlling the lamps in the T-6 display, the cockpit heating appliances, the ANO, the portable light, as well as the ARUFOSh lights, for heating the KKO, for the flap control aggregates, for the landing gear and the drag chute, for landing gear

position indication, for the speed brake control aggregates, for the ARK-10 units, as well as the firing button (sym. 18P), the ARU control aggregate,

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the relay (sym. 84M, 85M) for disconnecting the boosters from the hydraulic system, and the aggregates for checking pressure in the main and booster hydraulic systems.

Bus bar No 1 provides the supply for the engine start aggregates, for signalling when the generator is cut in, for the EUP-53, KLSRK, the afterburner regime aggregate, the fire extinguishing equipment aggregate, the aggregate for measuring the pressure in the hydraulic system, for signalling levels in the fuel tank in use, as well as in the suspended tank, for the pumps for the 1st and 3rd groups of fuel tanks, for the clock heating element, and for the aggregates which automatically release the wheel brakes.

Electric power consumers are grouped according to the type of operation they perform.

The aircraft equipment falls into the following functional groupings:

power;

engine operation and control;

cone control, flap control, air bypass, and throttle interlocking;

fuel;

aircraft control:

means for taking off and landing;

lighting equipment;

heating;

air navigation;

armaments;

radio supply.

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II. Electrical Network

1. General Information

The electrical network installed in the aircraft is a single-wire system, with the negative side grounded to the airframe, and the positive side led to the aggregates through cables insulated from the airframe.

The appliances supplied from the F-14A and F-14VT electrical filters are connected to the internal network by a two-wire system.

2. Type, guage, laying and plugging in of cables

The electrical network installed in the aircraft is, for the most part, made up of type BPVL and BPT cables of various guages (0.5 - 70.0 mm^2), depending upon the amount of current required by the aggregate.

The BPVL cables in the aircraft are color-coded as follows:

RED - armaments electrical systems;

BLUE - radio equipment electrical system;

WHITE - electrical equipment electrical system.

BPVL cable is not heat resistant. It is used for installations in zones where temperatures are normal, that is, in the cockpit, above and below the leading section of the fuselage, upper (two words obliterated) equipment, wing, fin.

BPT cable is heat resistant. It is used for installations in zones where temperatures are elevated: in the engine zone, the afterburner zone (tail section). In high temperature zones TM-250 conductor, having a guage of 0.75 - 6 mm^2 is used.

Cables are grouped in individual runs and are laid behind the instrument panels, and along the sides of the cockpit behind the consoles. These are the cockpit and cockpit control runs.

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In the fuselage is the upper fuselage control run, the upper fuselage run, the run in the nose section of the fuselage (frames 1-11), the run supplyin the radio, the run along the port side of the fuselage, the run along the starboard side of the fuselage, the control run along the starboard side, the lower fuselage run, the power runs, the runs to the pumps in the 1st, 2nd, and 3rd groups of tanks, and others.

In the tail section of the fuselage, and in the fin, are the main run in the tail section, and the run for controlling the tail section.

The wings contain: the runs in the removable section of the port wing-- the armament run, those for the flaps, floodlights, and the main landing gear; the runs in the removable section of the starboard wing-- the armament run, and the run for the main landing gear, and others.

All runs are protected by tubing made of AKhKR wire mesh. Additional protection, in areas where high temperatures prevail, around the engine, for example, is provided by the use of duralium tubing, tubing made of 14V22 heat resistant rubber, and AAS and ANZM wire mesh coverings. Hoses made of armored rubber, and other materials, are used in areas where there are sharp edges.

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The cable runs are secured in place with normally used, rigid and pliable fasteners.

Rigid fasteners (locks and clamps) are secured to the aircraft structure.

Pliable fasteners (pliable metal clamps, straps made of chlorovinyl plastic) are used to connect individual runs to each other.

3. Cable Markings

The cables in the aircraft's electrical network are marked for convenience of assembly and disassembly, as well as to facilitate finding and eliminating troubles. The cable marking system consists of letters and numbers and

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presupposes that instructions will be placed on individual cable tags.

1. Groupings for electrical equipment aggregates.

All special equipment in the aircraft included in this category has been divided into 10 groups, according to purpose, as follows:

Group Letter	Name of equipment included in group
1	2
E	Power system equipment (sources of supply)
M	Electrical devices
Ye	Ignition aggregates
K	Check instruments
S	Light signals and illumination
	Page 20
N	Air navigation equipment
T	Instrument heating
R	Radio equipment
P	Armament
B	Tanks

2. The ordinal number of an aggregate contained in one of these groups.

3. The number of the cable run (this will depend upon the number of cables coming out of a given aggregate).

4. The number of terminals for the plug, or aggregate, to which the cable must be connected.

5. The location to which the particular cable runs.

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An example is:

4 55R1 - 36R

where:

4 is the number of plug terminals to which the cable must be connected;

55 is the ordinal number for the aggregate contained in the particular group;

R is the group letter (radio equipment)

1 is the number of the cable run coming from the equipment;

36R is the location to which the particular cable runs.

4. Connecting and distributing devices - plugs, electrical switchboards

A. Plugs

Honeycomb connector plugs, type ShR (Sh-connector, R-plug), and type ShRG (Sh-connector, R-plug, G-airtight), have been installed in the aircraft to facilitate installation and removal of individual aggregates and electrical runs.

The type ShR plugs are used to connect individual sections of electrical circuits which need not be hermetically sealed, such as relay boxes, the electrical switchboards which are part of the port and starboard consoles in the cockpit, the nose and tail sections of the fuselage, the wings, and the fuselage.

The ShRG plugs provide a means for bringing the electrical cables through the airtight wall of the cockpit.

Figure 5 shows the location of the electrical plugs in the aircraft.

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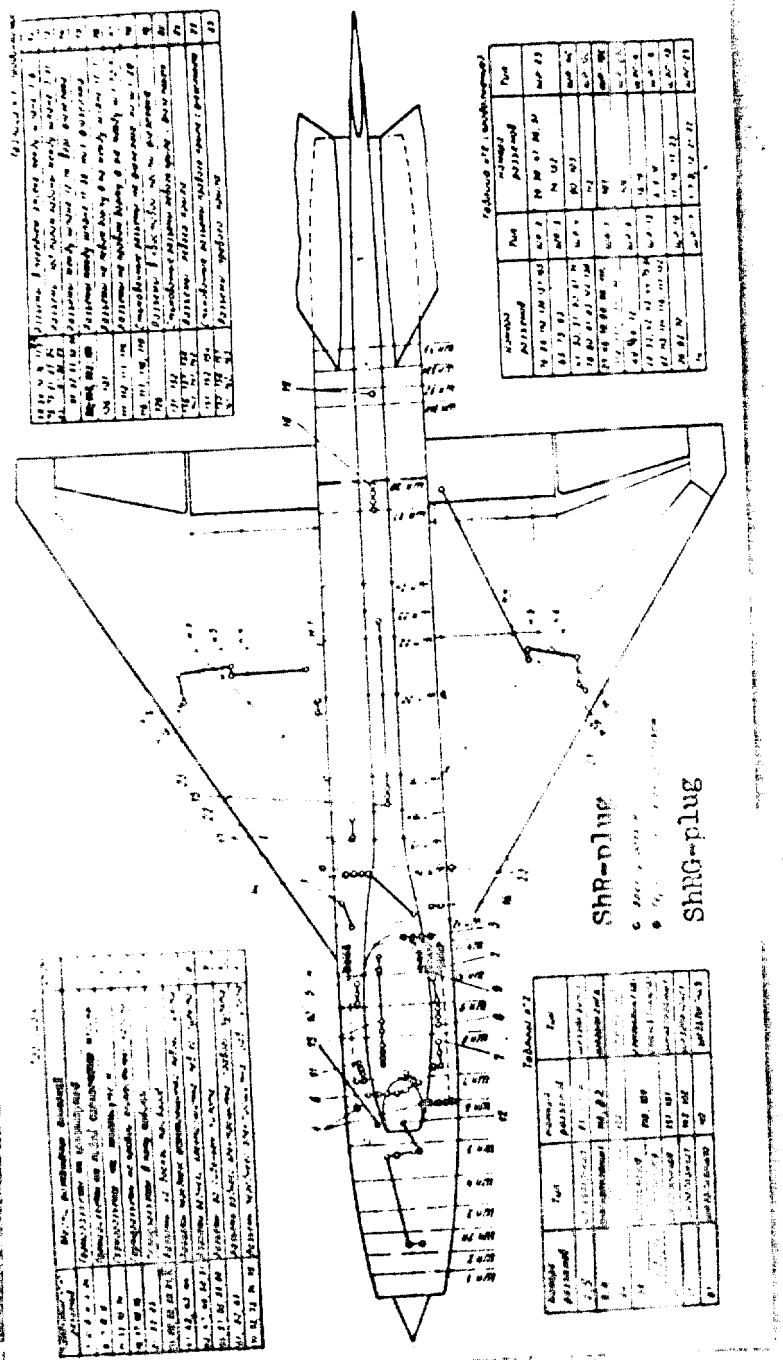

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B. Electrical switchboards

The electrical equipment installed in the aircraft has automatic circuit breakers as well as manual switches. The breakers and switches have been centralized on separate electrical switchboards.

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Schematic diagram of electrical plug locations throughout the aircraft.

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The switchboards are located in the cockpit on the starboard and port consoles and include:

the forward electrical switchboard for the starboard console;

the after electrical switchboard for the starboard console;

the electrical switchboard for the port console.

In order to provide for easy removal of the electrical switchboards, the latter have cable runs which terminate in connector plugs.

The forward electrical switchboard for the starboard console (figure 6) is installed on the vertical section of the starboard console, between frames number 7 and 8 and consists of two blocks of circuit breakers and switches installed on a single panel.

An AZS (sym. 22R) is installed above the forward switchboard - "In the event of failure of PO-750:MRP, RVU" - to protect the circuit and to furnish the supply to the winding of the relay (sym. 18R) which, when energized, cuts in the supply to the RVU, MRP station.

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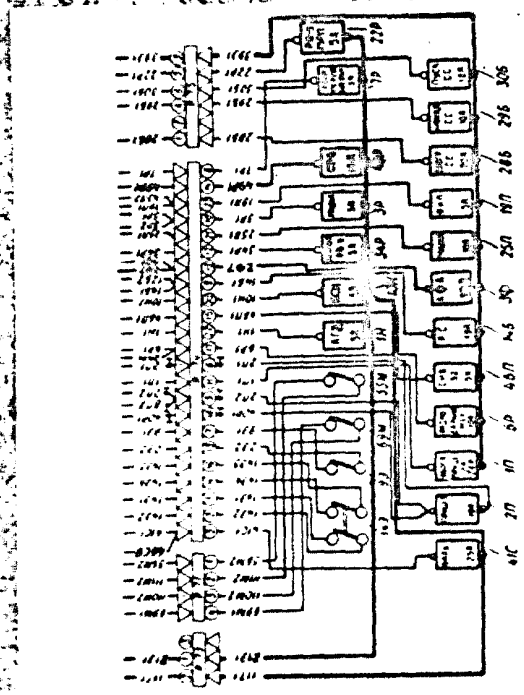

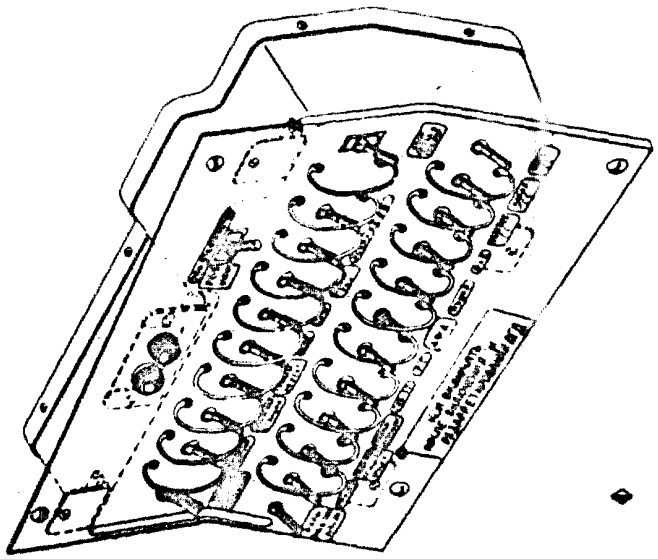

Figure 6. Forward Electrical Switchboard for the Starboard Console and the Electrical Schematic

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Upper Block

Switch 2V-45 (sym. 14E) - "Aircraft storage batter-airfield" - for cutting in and cutting out the aircraft storage batteries 15-STsS-45 and the source of supply used while on the ground.

Switch VTK (sym 9E) - "Generator" - for cutting in and cutting out the GSR-ST-12000VT starter-generator.

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Figure 6. Forward electrical switchboard for the starboard console and the electrical schematic

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Switch 87K (sym. 69M) - "Pump Station" - for supplying power from the aircraft network to the contactor for cutting in the pump station NP-27T.

Switch 87K (sym. 55M) - "Trim Effect" - for delivery of current to the switch controlling the MP-100M electric motor for the loading mechanism.

AZS-5A (sym. 1N) - "AGD" - for circuit protection and delivery of current to the STsGV (sym. 24N) hydraulic transmitter for the AGD-1 unit and to the relay (sym. 19N) for starting the PT-500Ts (sym. 2N) converter.

AZS-5A (sym. 10N) - "KSI" - for circuit protection and delivery of current to the KSI course system and to the relay (sym. 16N) for starting the PT-500Ts (sym. 2 N) converter.

AZS-5A (sym. 34 (letter obliterated)) - "MRP-RVU" - for circuit protection and delivery of current to the relay (sym. 27R) for energizing RVU-MRP and to MRP-56Ts.

AZS-5A (sym 3R) - "Radio station - oil pressure" - for circuit protection and delivery of current for the relay energizing the radio station (sym. 9R), the "ABV" block (sym. 10R) and amplifier UK-2M of series Ye connected to

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radio station RSIU-5 (letter obliterated). (Translator's Note: Translation made with reserve because of condition of text).

AZS-10A (sym. 49R) - "SM" - for circuit protection and delivery of current to the responder ORO-1 (possibly SRO-1)

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AZS-5A (sym. 7R) - "Emergency Converter Switch" - for circuit protection and delivery of current to the relay winding (sym. 32R) for emergency converter switch.

AZS-5A (sym. 22R) - RVU, MRP" - for circuit protection and delivery of current to the relay winding (sym. 18R) for energizing MRP-RVU in event of failure of PO-750A and to the relay winding (sym. 57R) for disconnecting PO-750A.

Lower Block

AZS-25A (sym. 41S) - "Floodlights, external signal landing gear" - for circuit protection and delivery of current to switch for controlling the navigational and landing flood lights (sym. 43S, 44S).

AZS-10A (sym. 2P) - "Sight" - for circuit protection and supplying the voltage from the aircraft network to the sight block ASP-5ND.

AZS-20A (sym. 1P) - "Sight, sight heater" - for circuit protection and delivery of current to filter F-14A (sym. 4P) of sight ASP-5ND.

AZS-5A (sym. 6R) - "SR Range Only" - for circuit protection and delivery of current to the radio range and to the relay (sym. 8R) for energizing the range-only radar.

AZS-5A (sym. 46P) - "SNV" - for circuit protection and delivery of current to the winding of the relay (sym. 48R) for starting converter PO-500A (sym. 15R) and providing block which supplies SIV-52 with 115 volts, 400 cycles a.c.

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AZS-10A (sym. 14B) - "RS" - for circuit protection and delivery of current to the RS block.

AZS-10A (sym. 3F) - "AFA" - for circuit protection and delivery of current to the block for the aerial camera AFA-39.

AZS-10A (sym. 25P) - "Cannon" - for circuit protection and delivery of current to the electric trigger and to the valve for reloading the cannon.

AZS-5A (sym. 19P) - "FKP" - for circuit protection and delivery of current to the timing mechanism VM-2 and to the gun camera SSh-45-1-100-SS.

AZS-20A (sym. 28B) - "SS Heater" - for circuit protection and delivery of current to K-13 missile system heater element.

AZS-10A (sym. 29B) - "SS Filament" - for circuit protection and delivery of current for the tube filaments of the K-13 system.

AZS-10A (sym. 30B) - "SS Launch" - for circuit protection and delivery of current for launching missiles in the K-13 system.

After electrical switchboard for the starboard console (figure 7) is installed on the vertical section of the starboard console in the cockpit between frames 9 and 10 and consists of two blocks of circuit breakers and switches, mounted on one panel.

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Upper Block

AZS-10A (sym. 9B) - "Emergency dump R.S., tank, APU, emergency launch SS" - for circuit protection and delivery of current to the button for emergency drop RS, APU-SS (sym. 23B), to the tank drop button (sym. 10B), and to the Emergency Launch "SS" button (sym. 22B), as well as to the lock (sym. 41B and 40B) of the APU suspension.

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AZS-5A (sym. 68M) - "Manual control ARU" - for circuit protection and delivery of current to the control block (sym. 62M) and ARU-3V automaton (sym. 73M).

AZS-5A (sym. 87M)- "ARU control automaton" - for circuit protection and delivery of current to control block ARU-3V (sym. 62M).

AZS-5A (sym. 17P) - "Cannon, SS, RS, FKP" - for circuit protection and delivery of current to the firing button.

AZS-5A (sym. 1B) - Suspension signal, RS, APU" - for circuit protection and delivery of current to the lights for signalling suspension of RS, APU.

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Figure 7. Rear electrical switchboard of starboard console and electrical schematic

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AZS-15A (sym. 5R) - "ARK" for circuit protection and delivery of current to the automatic radio compass ARK-10.

AZS-5A (sym. 31E) - Check lamp T-4, T-6" - for circuit protection and delivery of current to displays T-6 and T-4, the lights for signalling fuel remaining and trim effect.

Lower Block

AZS-5A (sym. 2S) - "Landing gear signal, ANO" - for circuit protection and delivery of current to the pilot lights for signalling

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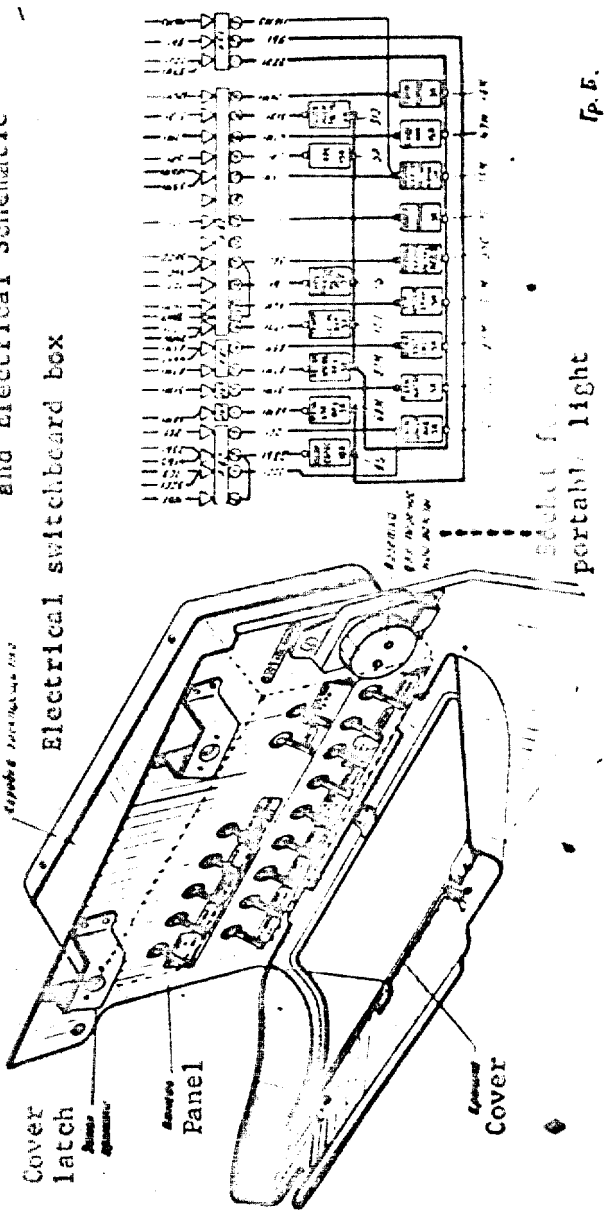

Figure 7. Rear Electrical Switchboard of Starboard Console and Electrical Schematic

Electrical switchboard box

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landing gear strut position and the switch for BANO light strength.

AZS-5A (sym. 22S) - "Speed brakes" - for circuit protection and delivery of current to the hydraulic-electric valve for extending speed brakes (sym. 122M and 32M).

AZS-5A (sym. 83M) - "Disconnect booster system" - "hydraulic system signal" - for circuit protection and delivery of current to the push button (sym. 90M) for disconnecting the booster system from the boosters for the stabilizer and from the booster for the ailerons, to the pilot lights (sym. 43K and 44K) for signalling lack of pressure in the hydraulic system and to the winding of the relay (sym. 45K) for signalling a drop in pressure in the booster system.

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AZS-5A (sym. 34M) - "Landing gear flaps" for circuit protection and delivery of current to the switch (sym. 35M) for lowering and raising the landing gear and to the mechanism for controlling flaps (sym. 39M).

AZS-5A (sym. 35S) - "ARUFOSH", portable lamp, KKO, AGD heater" - for circuit protection and delivery of current to the socket for energizing the portable lamp (sym. 36S and 45S), to the push button (sym. 21T) for rapid heating of the air-tight helmet and to the RUFO-45 rheostats (sym. 38S, 39S).

AZS-5A (sym. 1T) -"Cockpit heat" - for circuit protection and delivery of current to the switch (sym. 2T) for manual and automatic cockpit heat.

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AZS-10A (sym. 33M) - "Cone and throttle interlock" - for circuit protection and delivery of current to the switch (sym. 54M) for automatic and manual control of the cone, for the filters in the "M" number controllers (sym. 50M and 125M), the switch for controlling the valves for by-passing air (sym. 120M), the electro-pneumatic valve for controlling air purging of the station RSIU EMO-2/2.

AZS-15A (sym. 47M) "Seat" - for curcuit protection and delivery of current to the electric motor for controlling the seat (sym. 45M).

AZS-5A (sym. 46M) - "Drag-chute" - for circuit protection and delivery of current to the push button (sym. 129M and 131 M) for streaming and dropping the drag-chute.

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Electrical switchboard for the port console (figure 8)

This switchboard is installed in the vertical portion of the port console in the cockpit between frames numbers 7 and 8 and consists of two blocks of circuit breakers and switches located on a single panel.

Upper Block

Push button 204KS (sym. 58M) under a protective cover - "Engine cut-off valve" - for delivery of current from the aircraft network to the engine cut-off valve (sym. 52M).

AZS-10A (sym. 20M) - "Wheel brakes" - for circuit protection and delivery of current to the electro-pneumatic valves (sym. 23M, 22M and

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92M) for releasing the brakes of the starboard, port, and nose wheels of the landing gear.

AZS-5A (sym. 9M) - "Pump No. 3" - for circuit protection and delivery of current to contactor KM-50D (sym. 17M) for energizing pump number 3 and to the pilot light (sym. 4K) for signalling operation of the pump for the group of tanks.

AZS-5A (sym. 14M) - "Pump No. 1" - for curcuit protection and delivery of current to contactor KM-50D (sym. 12M) for energizing pump number 1 and to the pilot light (sym. 6K) for signalling operation of the pump for the group of tanks.

AZS-5A (sym. 13K) - "EDM, hydraulic fuel system signal supply to service tanks" - for circuit protection and delivery of current to the signal devices (sym. 1K and 15K) for fuel pressure during operation of the Group 2 tanks and suspended tank and to the 2EDM-50 indicator (sym. 11K).

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Figure 8. Electrical switchboard for port console and electrical schematic

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AZS-5A (sym. 9K) - "Fire system, deicer for canopy, cut-off valve" - for circuit protection and delivery of current to pushbutton (sym. 53M) for energizing the cut-off valve, to pushbutton (sym. 5T) for energizing the deicer, to the push button (sym. 22K) for cutting in the fire extinguisher and the inertial signal device IS-2MS (sym. 24K).

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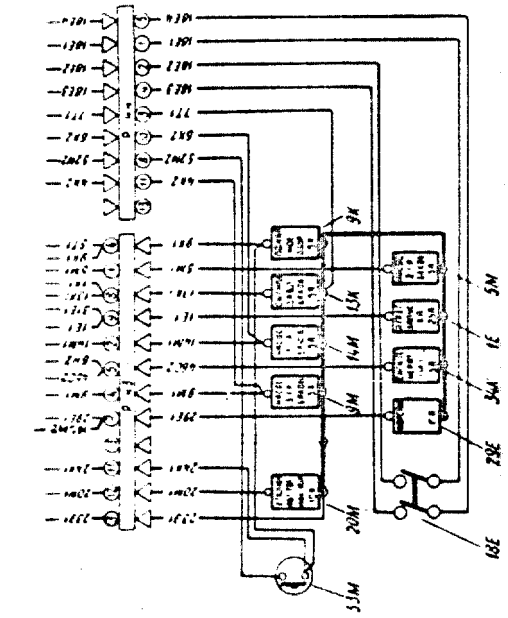

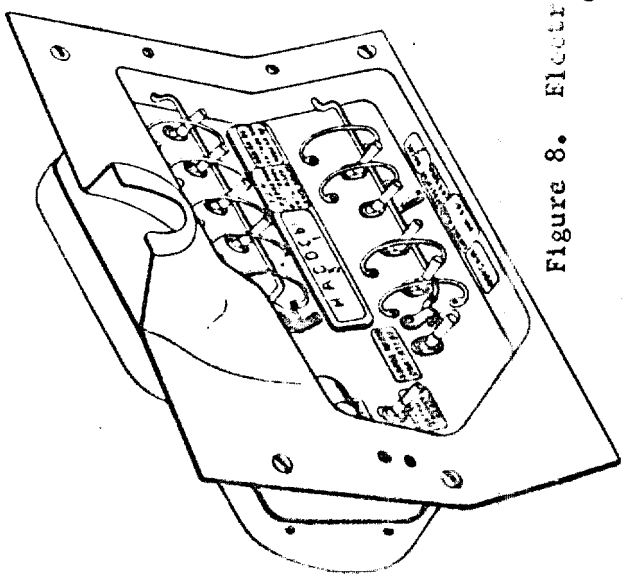

Figure 8. Electrical switchboard for port console and electrical schematic

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Lower Block

Switch 2V-45 (sym. 18K) - for cutting in the circuit for turning over the engine when cold and for starting the engine on the ground.

AZS-10A (sym. 29Ye) - "After burner" - for curcuit protection and delivery of current to the after burner automaton box KAF-13D (sym. 97M), to the switch (sym. 145K), to terminal switch for hydraulic decelerator (sym. 34Ye) and to KVS-1 (sym. 151D) signal distribution box.

AZS-5A (sym. 34K) - "Generator signal (ZUP, KIS" - for circuit protection and delivery of current to ZUP-53 (sym. 6N), KLSRK-15 (sym.1S), to the pilot light (sym. 17S) for signalling "generator on" and to the relay (sym. 17E) for energizing (two words blurred).

AZS-25A (sym. 1Ye)"Start-up aggregate" - for circuit protection and current supply to starter relay box KPR-15 A (sym. 4M), to (word blurred) AV7-44-5 (sym. 1M), and switch (symbol and two words blurred) of the engine.

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AZS-5A (sym. 5M) - "Pump No. 2" - for circuit protection and delivery of current to contactor KM-50D (sym. 6M) for energizing Pump No. 2.

5. Electrical circuit protection

The elements employed in the aircraft for circuit protection are circuit breakers and fuses of the following types:

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circuit breakers - AZS and AZR;

fuses IP and SP.

Circuit breakers and fuses are installed in the circuits in accordance with the current values for the circuits and are marked in accordance with their rated values.

Examples: AZS-5, AZR-15, SP-5, IP-15, etc.

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6. Switch gear

The switch gear in the electrical network includes:

type TKD-203DT, TKYe-21PD, TKYe-52PD, TKYe-53PD, TKYe-65PD relays;

type VK2-141, VK2-140R, VK-44 terminal switches;

type KV-9A, KV-9 micro switches;

type PK-4, 2PP-45, PN-45M, PPN-45, 3PPN-45, 88K, P3PN-20, VT3-602-020SP and P2NPK-45 switches;

type 87K, 2V-45 switches;
type KM-25D, KM-50D, KM-100D, KM-400D, KP-400D contactors;
type 5KS, 204KS, 205KS push buttons.

The switch gear is, in the main, right in the relay and contactor boxes, as well as on the electrical switchboards. Figure 9 shows the locations of the boxes and of the switchboards.

Relay and contactor boxes.

The relay box at frame number 6 behind the instrument panel is part of the aircraft electrical network. Located in the box are the:

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TKYe-52PD relay (sym. 33E) - "disconnect relay for SRD, MRP, SIV-52 and RVU" for disconnecting the supply to the SRD, MRP, SIV-52 and RVU stations in the event the supply from the generator or from the airfield

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Figure 9. Schematic of the location of relay, contactor and fuse boxes and of the switchboards

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Figure 9. Schematic of the location of relay, contactor and fuse boxes and of the switchboards

1. Relay and fuse box PT-500Ts.
2. Relay box at frame number 6 behind instrument panel.
3. Forward switchboard for starboard console in cabin.
4. Start contactor and resistance box between frames number 7A and 8.
5. Relay and fuse box in lower compartment at frame number 9.
6. After switchboard for starboard console.
7. Contactor box.
8. Start contactor box.
9. Relay and fuse box in the power unit.
10. Contactor block.
11. Relay box between frames numbers 15 and 16.
12. Relay box in the tail section of the fuselage.
13. Switchboard for port console.
14. Relay and fuse box at frame number 11.
15. Relay box between frames numbers 11 and 12.

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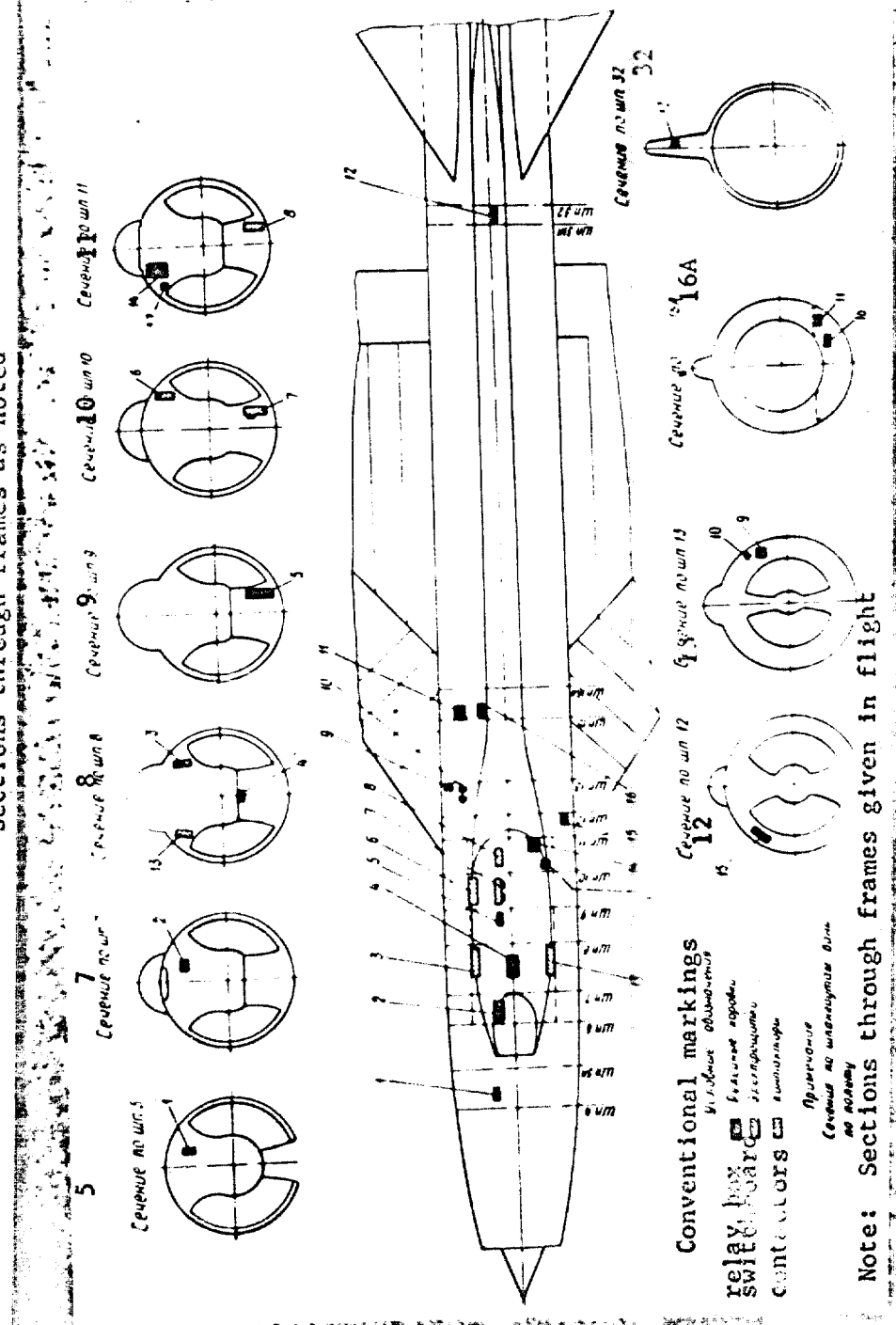

Figure 9. Schematic of the location of relay, contactor and fuse boxes and of the switchboards
Sections through frames as noted

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16. Relay box between frames numbers 15 and 16A.

17. Relay box for automatic SS launch.

source is disconnected.

TKYe-21 PD relay (sym. 38P) - "Relay for signalling cannon ready - for energizing the signal system indicating cannon is ready to fire.

TKYe-53PD (sym . 28P) "relay for energizing circuit for firing cannon and FKP".

TKYe-56PD relay (sym. 86M) - "relay for checking operability of lights in T-4 display" - for checking proper functioning of lights in the T-4 display and lights for signalling lack of pressure in the main and booster hydraulic systems.

TKD-203DA relay (sym. 17E) - "relay for disconnecting power consumers" for disconnecting the ASP-5ND sight and the K-13 system in event of lack of supply from the generator or from the airfield source.

TKYe-56PD relay (sym. 15Ye) - "relay for checking T-6 display lights" - for checking proper functioning of the lights used for signal purposes in the T-6 display.

TKYe-53PD relay (sym. 15S) - "relay for energizing landing gear external signal" - for energizing the lights signalling the position of the landing gear struts.

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SECRET
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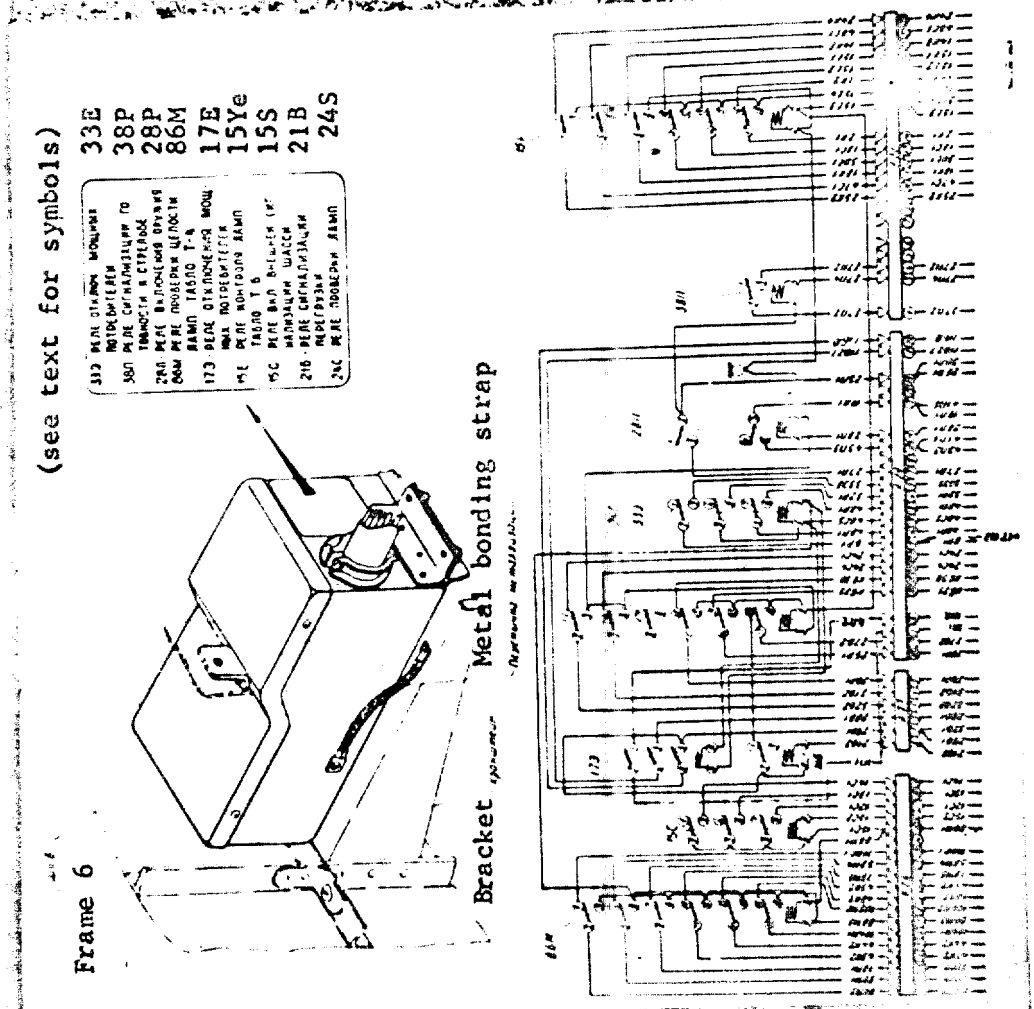

Figure 10. Relay box installation and circuit diagram.

NO FOREIGN DISSEM/NO DISSEM ABROAD/CONTROLLED DISSEM

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TKYe-21PD relay (sym. 21B) - "relay for energizing the overload signal."

TKYe-56PD relay (sym. 24S) - "relay for checking operability of signal lights."

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Figure 10. Relay box installation and circuit diagram.

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The relay box is installed above the instrument panel on the starboard side, at frame number 6.

Installation of the box and the electrical schematic is given in Figure 10.

Connector plugs numbers 26, 27, 29 and 30 are provided to permit the removal of the box from the machine and to disconnect it from the aircraft cable run which comes out of the box.

The relay and fuse box in the cabin at frame number 11 in the cockpit is part of the aircraft's electrical network and contains:

TKYe-53PD relay (sym. 126M) - "cone control relay" - for switching the circuit for energizing the hydro-electric valves for controlling cone position;

TKYe-53 PD relay (sym. 127M) - "cone control relay" - for switching the circuit for energizing the hydro-electric valves for controlling cone position;

TKYe-53 PD relay (sym. 4B) - for energizing the PKP;

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TKYe-21PD relay (sym. 45K) - "booster system pressure signal relay;"

TKYe-21PD relay (sym. 26P) - "relay for connection of firing from cannon and SS" - for closing the circuit to the relay windings (sym. 28P and 37B);

TKYe-21PD relay (sym. 34B) - "overload signal connection relay" - for closing " - "to relay winding (sym. 21B);

TKYe-52PD relay (sym. 37B) - " 'SS' firing relay";

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Figure 11

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TKYe-53PD relay (sym. 41P) - "relay for energizing RS and SSb" - for closing circuit for firing rockets and energizing FKP;

TKYe-52PD relay (sym. 76M) - "relay for controlling and signalling lowering of flaps" - for closing circuit to energize the hydro-electric valve for lowering flaps (sym. 44M) and for signal light;

TKYe-53PD relay (sym. 51M) - "relay for protecting regulator and DMR-400D from 48V;"

TKYe-53PD relay (sym. 116M) - for blocking the throttle at M number $\geq$ 1.5;

TKYe-21PD relay (sym. 141M) - "relay for controlling anti-pumping valves for the after-burner" - for closing and opening the valves for by-passing air according to cutting in and cutting out the after-burner.

The relay box is installed on the port side near frame number 11.

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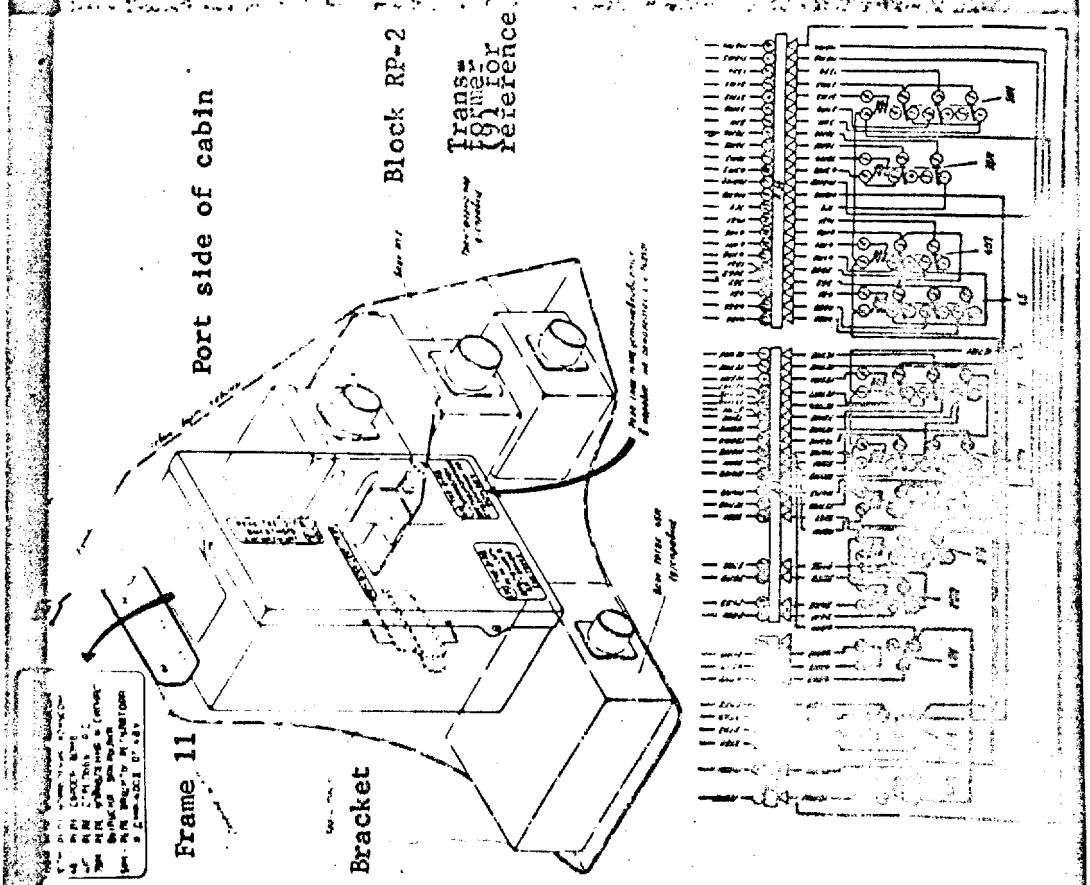

Figure 11

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The installation, as well as the electrical schematic, is shown in figure 11.

Connector plugs numbers 50, 56, 57, and 59 are provided to permit the removal of the box from the cable runs.

The relay and fuse box in the lower compartment at frame 9 is part of the aircraft's electrical network. Located within the box are:

TKYe-56PD relay (sym. 32R) - "emergency supply relay" - for switching the circuits for the radio equipment to emergency supply;

TKYe-52PD relay (sym. 17R) - "for energizing PO-750A No 1 and VRD supply from ARK" for starting the PO-750A (sym. 1R) when the ARK is energized;

TKYe-52PD relay (sym. 48R) - "energizing PO-500~115 volts for SIV" serves to start the PO-500A (sym. 15R) when the AZS (sym. 46P) "SIV" is energized and deliver~ 115 volts to the SIV supply block;

TKYe-52PD relay (sym. 53R) - "energizing PO-750A No 2~115 volts for RVU" for starting PO-750A (2R) when AZS (34R) "RVU, MRP" is energized and to deliver a~ 115-volt supply to the RVU transceiver;

TKYe-52PD relay (sym. 9R) - "energizing PO-750A No. 1~115 volts for radio" serves to start the PO-750A converter (sym. 1R) when the AZS (sym 3R) "Radio Station" is energized and to deliver a~115 volts to the "ABV" block of station RSIU-51;

TKYe-52PD relay (sym. 28R) - "energizing PO-750A No. 2~115 volts for range-only radar" serves to start PO-750A (sym. 2R) when the AZS (6R)

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"range-only radar" is energized and to deliver ~ 115 volts to the range-only radar block;

TKYe-52PD relay (sym. 40R) - "energizing PO-500A ~ 115 volts for sight" - serves to start PO-500A (15R) when the sight circuit breaker is energized and to deliver ~ 115 volts to plug "P" of sight ASP-5ND;

TKYe-21PD relay (sym. 27R) - "energizing RVU-MRP" serves to supply the winding of the relay (sym. 53R) for starting PO-750A (sym. 2R) from RVU-MRP;

TKYe-56ND relay (sym. 18R) - "energizing MRP-RVU in event PO-750A current fails;"

TKYe-21PD relay (sym. 8R) - "energizing range-only radar" serves to deliver current to the winding of the relay (sym. 28R) for starting PO-750A (sym. 2R) from the range-only radar;

TKYe-21PD relay (sym. 57R) - "disconnect PO-750A" serves to disconnect PO-750A (sym. 2R) when AZS (sym. 22R) is cut in;

TKYe-52PD relay (sym. 3P) - "energizing PO-500A for SS" serves to start PO-500A (sym. 15R) when port SS is suspended;

fuse SP-5 (sym. 14R) - "14R, Radio" in the supply circuit to station RSIU-5G;

fuse SP-5 (sym. 55R) - "55R, IS" in the supply circuit to the IS-2MS electronic amplifier;

fuse SP-2 (sym. 19R) - "19R, ARK" in the ARK-10 supply circuit;

fuse SP-5 (sym. 21R) - "21R, KIA, SP-5;"

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TKYe-52PD relay (sym. 20P) - serves to start PO-500A (sym. 15R) when starboard SS is suspended:

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Fuse SP-5 (sym. 30R) - "30R, PT" - in the fuel consumption meter supply circuit;

Fuse SP-5 (sym. 22Ye) - "22Ye, DIM" in the DIM-8T transformer supply circuit;

Fuse SP-5 (sym. 29R) - "29R - "SRD" " - in the range-only radar supply circuit;

Fuse SP-5 (sym. 20R) - "20R - sight" - in the ASP-5ND sight supply circuit;

Fuse SP-5 (sym. 47R) - "47R - SIV" - in the SIV-52 supply circuit;

Fuse SP-5 (sym. 37R) - "37R - RV-U" - in the RV-U supply circuit;

Fuse SP-5 (sym. 14P) - "14P - SS" - in the SS supply circuit;

Fuse SP-5 (sym. 14R) - "14R - Radio" - in the RSIU station supply circuit.

The relay box has been installed in the storage battery recess at frame number 9. Installation of the box and its electrical schematic is shown in Figure 12.

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Figure 12. Fuse and relay box in lower compartment at frame number 9

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Connector plugs numbers 84, 85 and 87 permit removal of the box from the machine and the disconnecting of it from the aircraft cable runs.

The relay box between frames numbers 11 and 12 on the port side is part of the aircraft electrical network. Located within the box are:

TKYe-52PD relay (sym. 12T) - "storage battery heater" - for cutting

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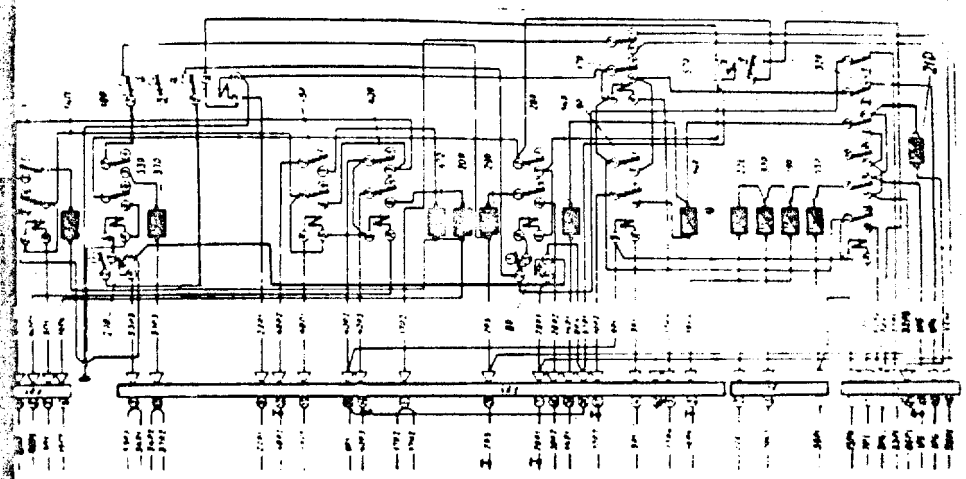

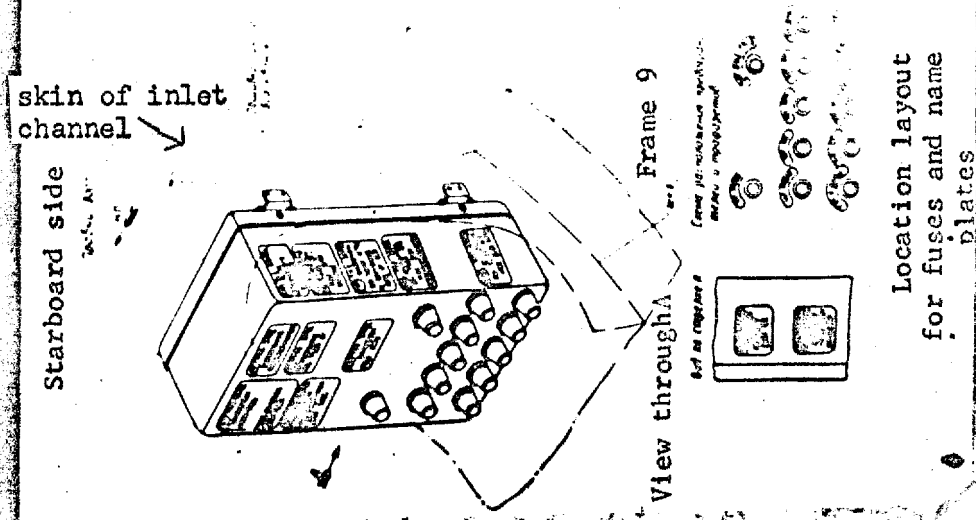

Figure 12. Relay and fuse box in lower compartment at frame number 9

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in the storage battery heater circuit;

TKYe-53PD relay (sym. 46S) - "signals for generator off and power consumers on" - for energizing the circuit to the light which signals "generator off," and for cutting out the power consumers (the pumps) in event of improper generator operation;

TKYe-21PD relay (sym. 18E) - "pump cut out in event of generator breakdown or disconnecting of ground supply;"

TKYe-53PD relay (sym. 13M) - "disconnect batteries for aircraft network when airfield supply source is connected;"

TKYe-53PD (sym. 20B) - "Blocking of firing thro[illegible] Landing gear" for prevention of rocket firing when landing gear struts are down;

TKYe-52PD relay (sym. 134M) - "release brakes" on nose wheel when brakes are released for starboard wheel;

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Figure 13. Relay box between frames numbers 11 and 12

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TKYe-52PD relay (sym. 93M) - "release brakes on nose wheel when brakes are released for port wheel;"

TKYe-21PD relay (sym. 48S) - "energize big light;"

TKYe-56PD relay (sym. 49S) "energize small light and floodlight control;"

TKYe-21PD relay (sym. 12Ye) - "block ignition system when on airfield power supply"

- for disconnecting the ignition coil when the ground supply source is

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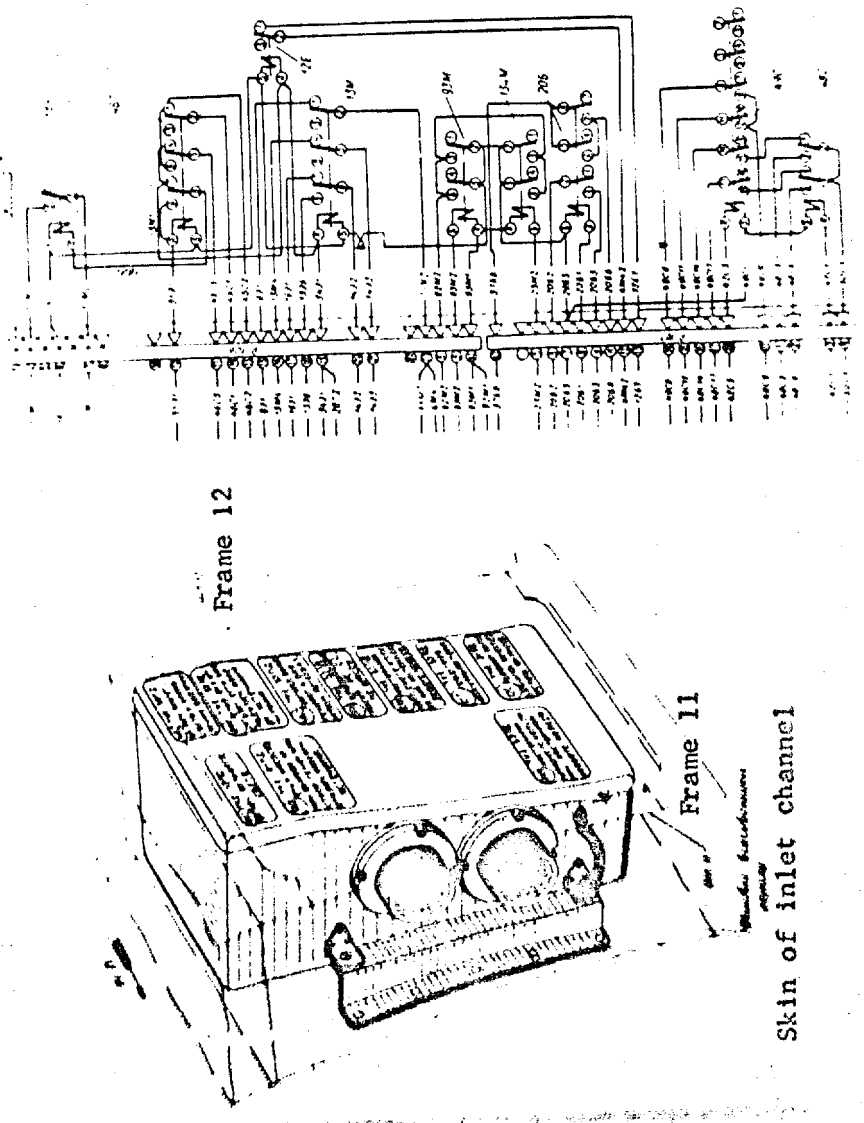

Figure 13. Relay box between frames numbers 11 and 12

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connected.

The relay box is installed on the port side of the fuselage between frames numbers 11 and 12.

Box installation and the electrical schematic is shown in figure 13.

Connector plugs, numbers 106 and 107, are provided to permit removal of the box from the machine and to disconnect it from the aircraft network.

The conservation box between frames number 15 and 16 is part of the aircraft's electrical network. Within the box are:

TKYe-52PD (sym. 84M) relay - "for disconnecting the aileron booster from the booster system;"

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Figure 14. Conservation box between frames numbers 15 and 16

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switch ZPPN-45 (sym. 14Ye) for engine conservation;

switch 88K (sym. 42M) for cutting in oxygen makeup for the engine;

switch 87K (sym. 40Ye) for inactivating the fuel dump valve "KS;"

fuse IP-10 (sym. 39Ye) in the circuit for the block of ignition coils KNA- 114;

fuse IP- 10 (sym. 32 Ye) in the circuit for the block of ignition coils KNA-114;

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* Direct translation. in certain instances "inactivate" will be used.

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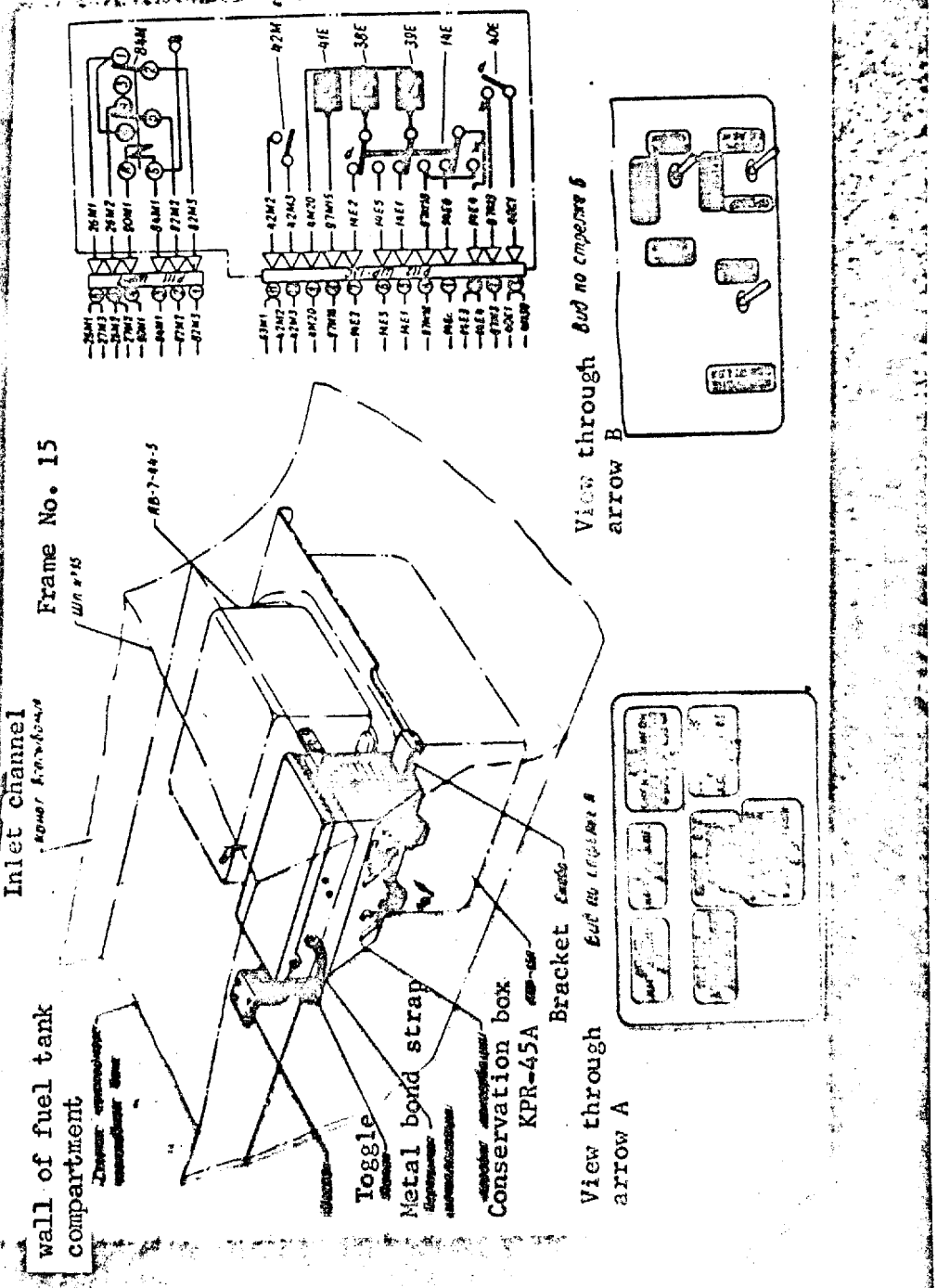

Figure 14. Conservation (inactivation) box between frames numbers 15 and 16

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fuse MP-5 (sym. 41Ye) in the circuit for the afterburner ignition coil, the pilot light for indicating 2nd carburetor ignition, and the signal distribution box KVS-1.

Connector plugs numbers 111 and 112 are provided to permit removal of the box and disconnecting the relay box from the on board cable runs.

Figure 14 shows the installation of the relay box and of the electrical schematic.

The relay box and fuses in the power unit are part of the aircraft's electrical network. Included in the box are:

the TKYe- 21PD (sym. 36E) relay - for disconnecting the generator from the aircraft network in the event power cables are ruptured.

fuse SP-5 (sym. 8E) - in the voltmeter circuit:

fuse (SP-5) - "power user relay disconnect" - in the relay circuit for generator disconnect upon power cable rupture.

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Figure 15. Relay box and fuses in the power unit.

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The relay box is located in the power system between frames 11 and 12, on the starboard side.

The cable run to the box contains one connecter plug, number 113.

The installation, and the electrical schematic, of the relay box is shown in figure 15.

The relay box in the tail section of the fuselage contains the TKYe-52PD relay (sym. 85M) "for disconnecting the stabilizer booster from

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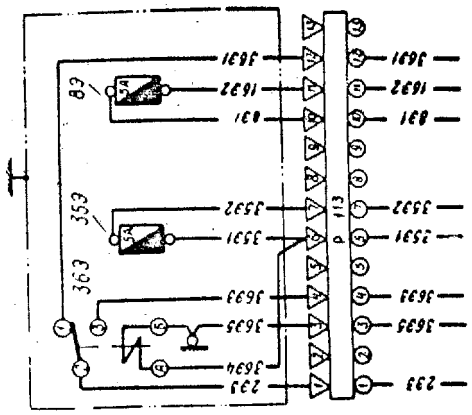

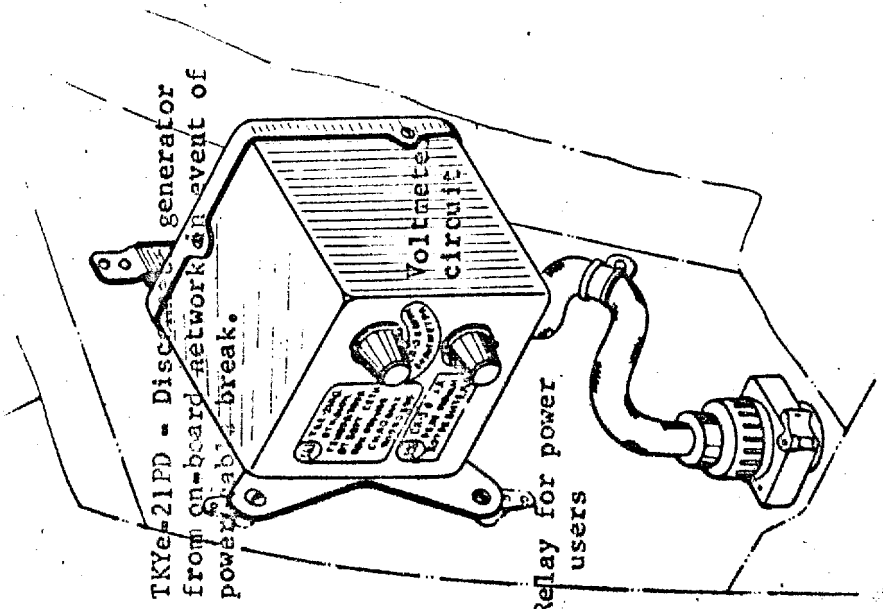

Figure 15. Relay box and fuses in the power unit.

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the hydraulic booster system."

The box is installed between frames 31A and 32. The cable run for the box contains one connector plug, number 126.

The installation, and the electrical schematic, for the relay box is shown in figure 16.

The start contactor box is part of the electrical network. Located in the box:

contactor KM-400D (sym. 38E) for energizing the generator start circuit through the starting resistance;

contactor KM-400D (sym. 37E) for energizing the generator start circuit and blocking the starting resistance;

starting resistance SP-0.05 ohm (sym. 5E).

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Figure 16. Relay box in the tail section of the fuselage.

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The box is installed in the storage battery recess between frames numbers 10 and 11. One connector plug, number 83, is provided for ease of removal of the contactor box.

The installation of the start contactor box, as well as the electrical schematic, is shown in figure 17.

The contactor box is a part of the electrical network. Contained within the box:

contactor KM-400D (sym. 19E) for cutting in the No. 1 storage battery; contactor KM-400D (sym. 25E) for cutting in the No. 2 storage battery; contactor KM-400D (sym. 27E) for switching the storage batteries

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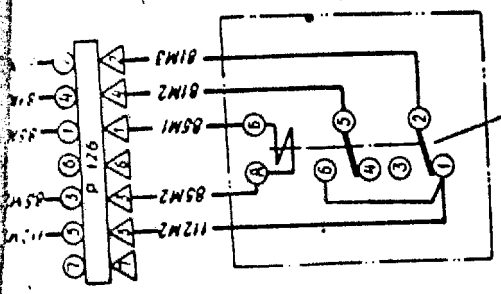

Figure 16. Relay box in the tail section of the fuselage

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to 48V; contactor KM-400D (sym. 28E) for switching the storage batteries to 48V.

The box is installed in the storage battery recess between frames number 9 and 10. The cable run for the box has two connector plugs, numbers 78 and 79, as well as cable exits.

Installation of the box, and the electrical schematic, are shown in figure 18.

The contactor block contains:

contactor KM-50D (sym. 12M) for connecting the pump in the 1st group of fuel tanks;

contactor KM-50D (sym. 6M) for connecting the pump in the 2nd group of fuel tanks;

contactor KM-50D (sym. 17M) for connecting the pump in the 3rd group of fuel tanks;

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Figure 17. Start contactor box.

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Figure 18. Contactor box.

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contactor KM-100D (sym. 70M) for cutting in the NP-27T pump station.

The contactor block is located between frames numbers 12 and 13 on the starboard side of the fuselage.

Figure 19 shows the contactor block installation, as well as the electrical schematic.

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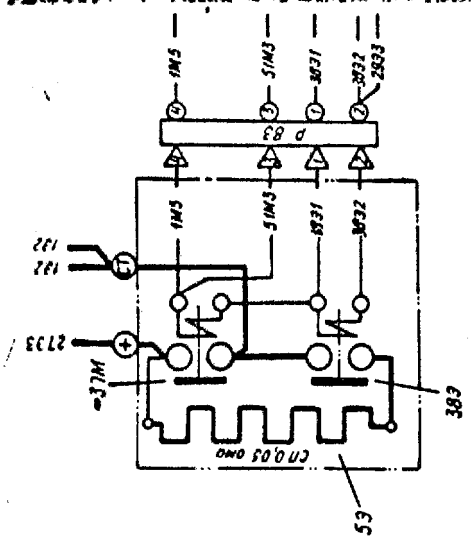

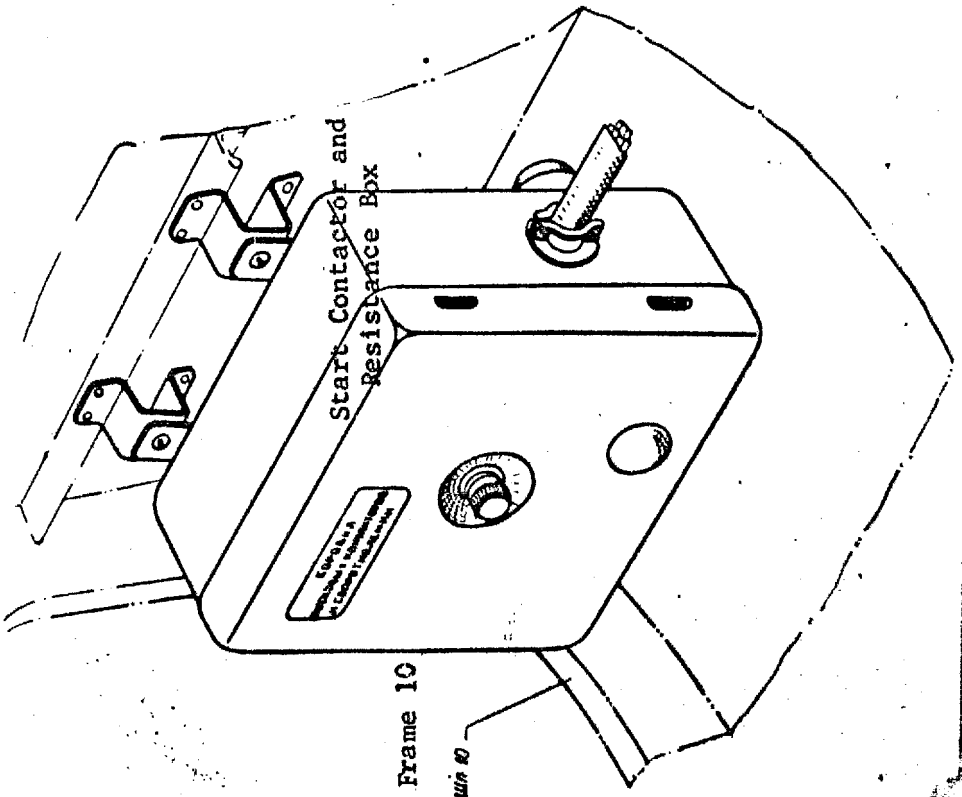

Figure 17. Start Contactor Box

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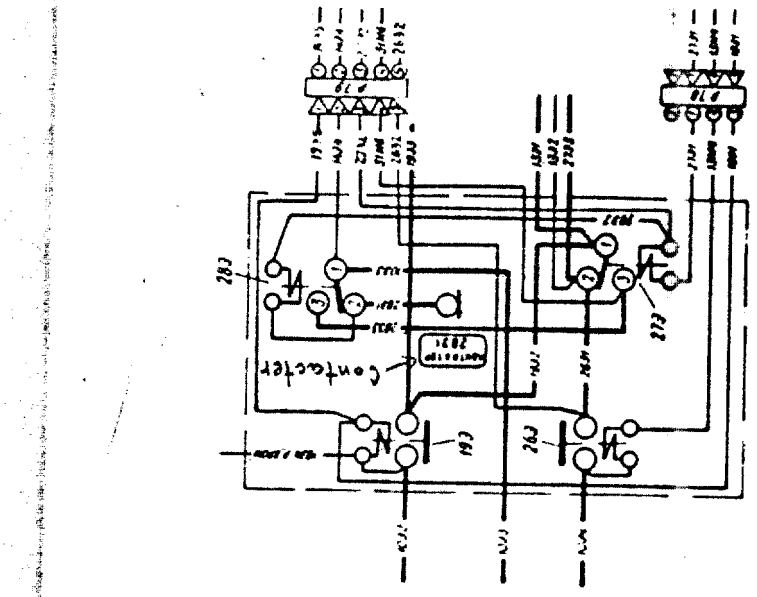

Figure 18. Contactor Box

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Relay box for automatic SS launching. The box contains:

TKYe-52PD relay (sym. 47P, 48P, 49P) for automatic SS launch;

TKYe-53PD relay (sym. 50R) for automatic SS launch;

The relay box is installed in the cockpit, frame number 11, port side. Connector plug No. 55 (Sh R-9) is provided in the cable run to the box to permit the removal of the box from the machine and to disconnect it from the aircraft circuit.

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Figure 19. Contactor block.

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Relay and fuse box PT-500Ts is part of the aircraft's electrical network. Contained within the box are:

TKYe-53PD relay (sym. 16N) - "relay for energizing KSI" - for starting PT-500Ts from KSI and for energizing the circuit for supplying the KSI circuit;

TKYe-53PD relay (sym. 17N) - "relay for energizing VRD" - for starting PT-500Ts from the "SRD" station and for energizing the circuit for supplying AGD, SRD, VRD;

TKYe-21PD relay (sym. 19N) - "relay for energizing AGD" - for starting PT-500Ts from AGD and for energizing the circuit for supplying AGD;

fuse SP-5 (sym. 20N) - "AGD" in AGD supply circuit;

fuse SP-5 (sym. 21N) - "AGD" - in AGD supply circuit;

fuse SP5 (sym. 22N) - "KSI" in the KSI supply circuit;

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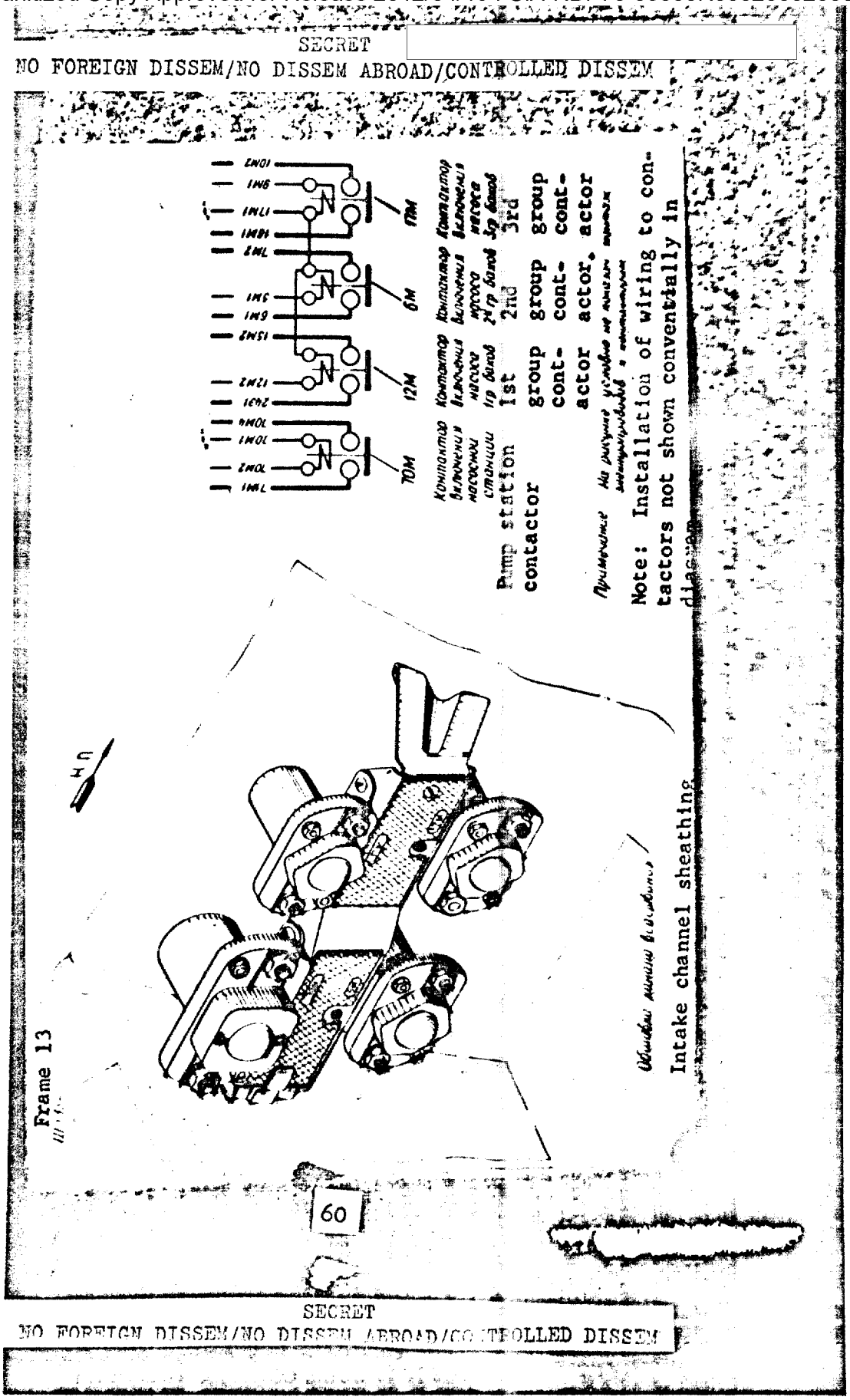

Figure 19. Contactor Block

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fuse SP-5 (sym. 23N) - "KSI" in KSI supply circuit.

The relay box is installed on the starboard side, between frames numbers 4 and 5 in the equipment hatch, upper part. The installation and the electrical schematic are shown in figure 20.

Connector plug number 70 is provided for ease in removing the box.

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Figure 20. Relay and fuse box PT-500Ts

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Contactor and resistor box between frames numbers 7a and 8 is part of the aircraft's electrical network. Contained within the box are:

contactor KP-50D (sym. 44E) - "voltage stabilizer in the ignition circuit;"

resistor SP-0.3 (sym. 45E) - "range multiplier in the ignition circuit" for reducing the voltage in the ignition coils during starting;

fuse IP-20 (sym. 42E) - "in the ignition circuit during series operation of the on-board storage batteries;"

fuse IP-20 (sym. 43E) - "in the ignition circuit during parallel operation of the on-board storage batteries."

The contactor and resistor box is installed on the starboard side between frames numbers 7A and 8.

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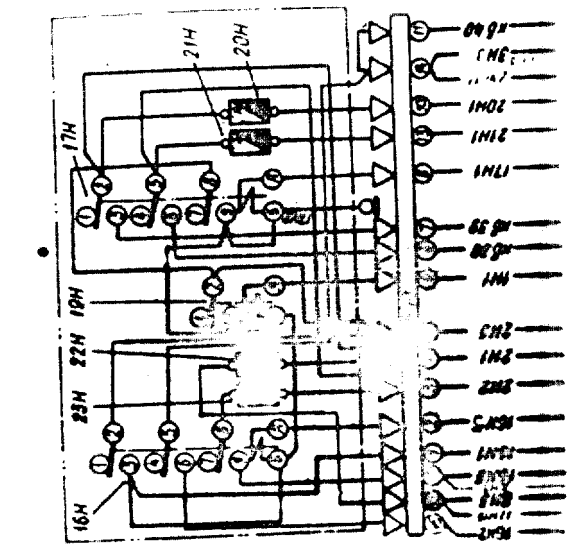

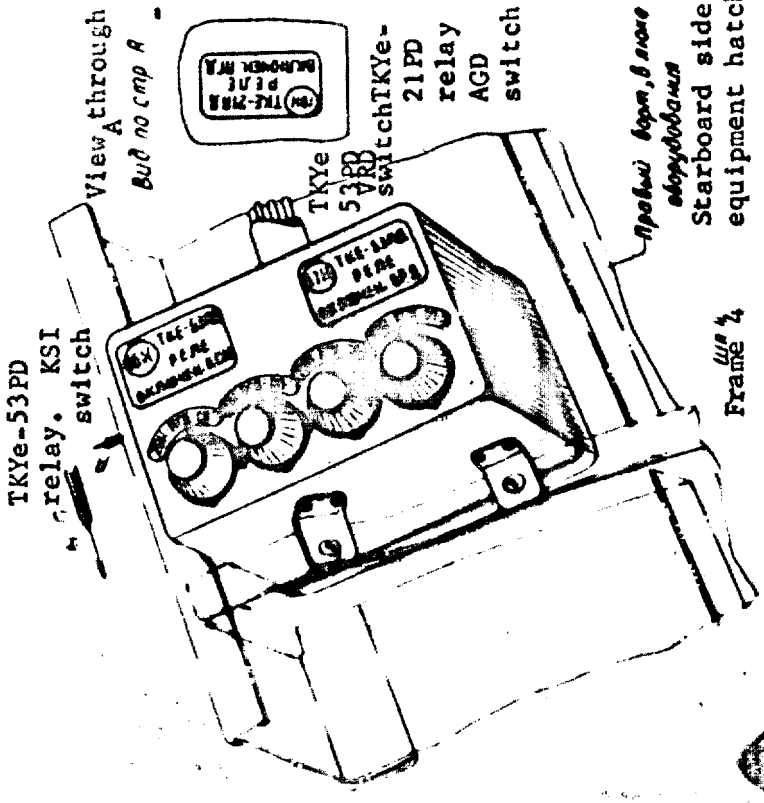

Figure 20. Relay and fuse box PT-500Is

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The installation and the electrical schematic for the box is shown in figure 21.

Connector plug number 89 is provided for ease in removing the cable run to the box.

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Figure 21. Contactor and resistor box between frames numbers 7A and 8.

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The relay box between frames number 15 and 16A is part of the aircraft's electrical network. Contained within the box are:

TKYe-52PD relay (sym. 28M) - "relay for setting flaps in afterburner position during start;"

TKYe-53PD (sym. 37M) - "relay for cutting off afterburner fuel when cutting out afterburner;"

TKYe-52PD relay (sym. 38M) - "relay for setting maximum flap position after start."

The relay box is installed between frames numbers 15 and 16A, starboard side, lower section.

The cable run for the box has connector plug number 1[illegible].

The installation and electrical schematic for the box are shown in figure 22.

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Figure 22. Relay box between frames numbers 15-16A

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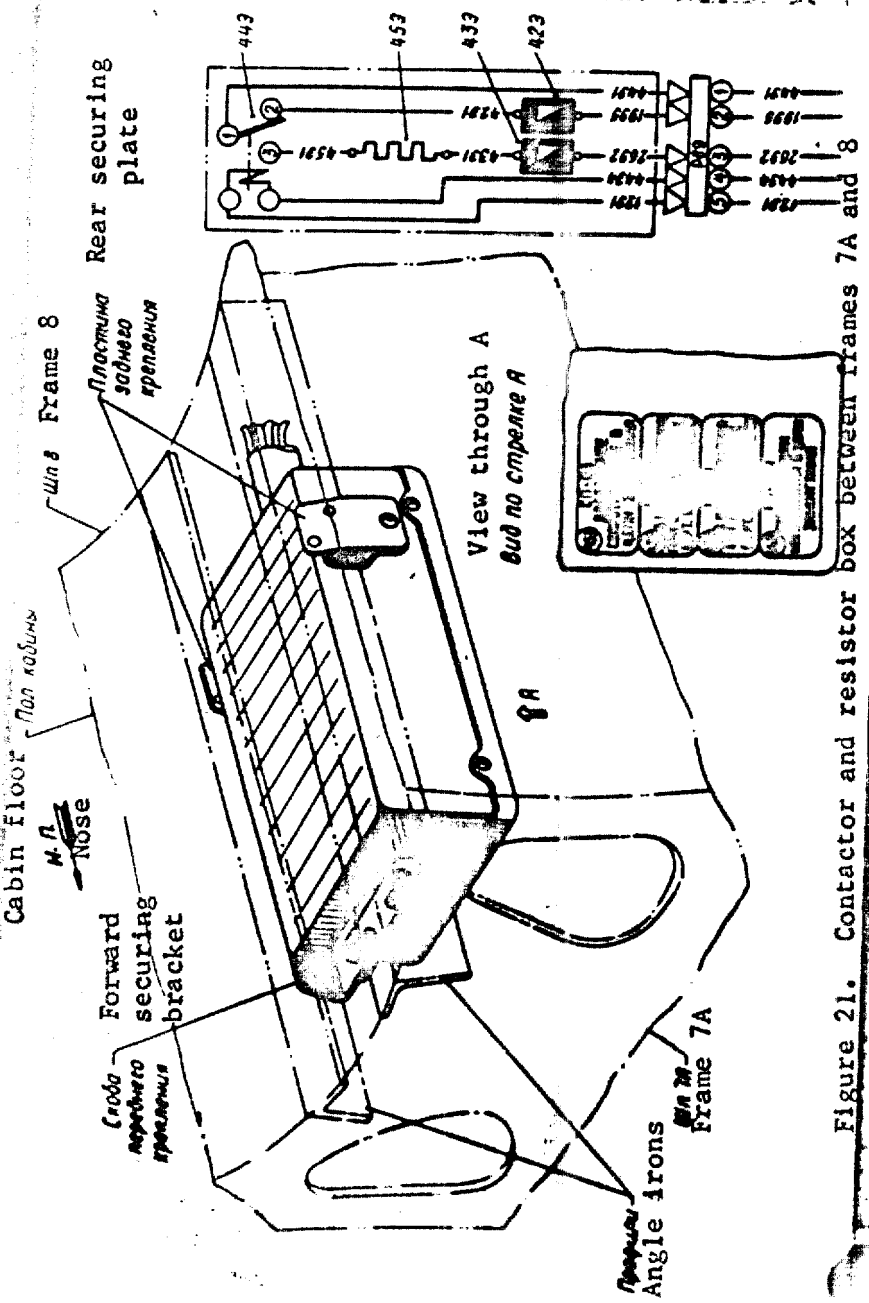

Figure 21. Contactor and resistor box between frames 7A and 8

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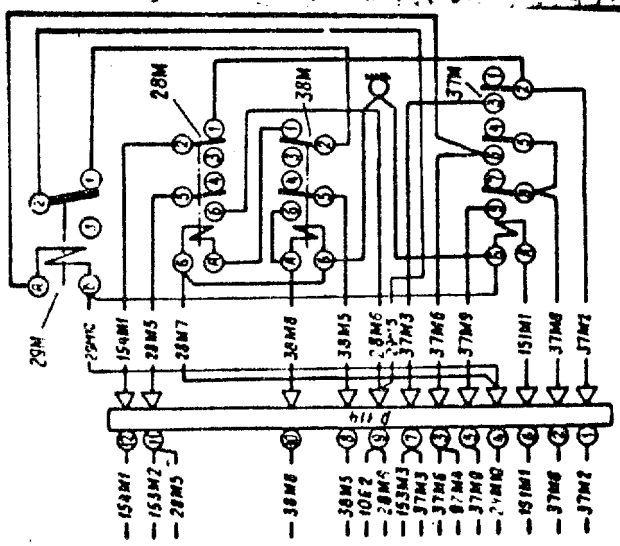

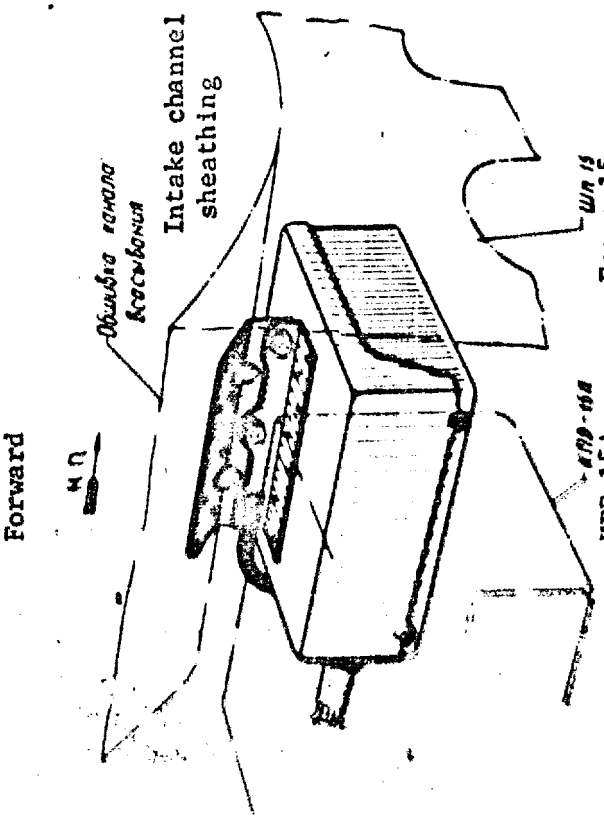

Figure 22. Relay box between frames numbers 15 and 16A

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7. Connecting negative leads

The negative leads are connected to the metal frame of the aircraft by the use of terminal lugs and bolts and anchor nuts.

For corrosion protection, as well as to make the locations for securing the negative leads stand out, the points at which the negative terminals are secured to the aircraft are painted with A-67F red enamel.

Figure 23 is the schematic showing the location of the points at which the negative leads are secured to the airframe.

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III. Electrical Systems

1. Power System

General Information

The power system is designed to provide the direct and alternating current voltages required by the electrical devices installed in the aircraft.

Operation of the pircraft power system is ensured by the electrical devices shown in the table.

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Locations of the main aggregates in the power system are shown in figure 24.

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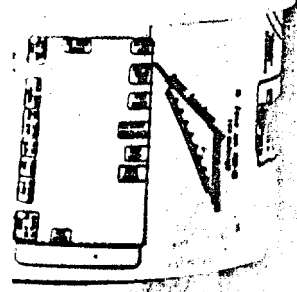

Figure 23. Schematic of location of connections of negative leads.

Фиг.23. Схема размещения подключений минусовых проводов.

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No.	Elec. circuit symbol	Item	Type	Quantity	Location
1	2	3	4	5	6
1	1E	Starter generator	GSR-ST-12000VT	1	Underneath engine frame 28
2	10E	Storage battery	15STsS-45	2	Head section of fuselage, below frames numbers 7A-8
3.	7E	Transformer	TS-EM	1	Upper section of fuselage, starboard side, frames 11-12
4	3E	Voltage regulator	RUG-82	1	Port side of fuselage, frames 12-13
5	2E	Differential-minimum relay	DMR-400D	1	Upper part of fuselage, starboard side, frames 11-12
6	37E	Contactor	KM-400D	1	Start contactor box, head section of fuselage, below frames 10-11

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7	38E	Contactor	KM-400D	1	Start contactor box, lower part of fuselage, frames 10-11
8	5E	Starting resistor	SP-0.05 ohm	1	ditto
9	25E	Remote resistor	VS-20	1	Starboard console in cockpit, between frames 9-10
10	16E	Voltmeter	V-1	1	Starboard fixed section of the instrument panel

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No	Elec. circuit symbol	Item	Type	Quantity	Location
1	2	3	4	5	6
11	27E	Contactor, selector	KP-400D	1	Contactor box, fuselage, lower, frames 9-10
12	28E	Contactor, selector	KP-400D	1	ditto
13	19E	Contactor	KM-400D	1	ditto
14	26E	Contactor	KM-400D	1	ditto
15	4E	Ammeter shunt	ShA-2	1	Power unit, starboard side fuselage, frames 11-13
16	6E	Condenser	KBM-31	3	Wall, frame 11, starboard side fuselage (power unit)
17	13E	Plug receptacle for taking airport source of supply	ShRA-250MLK	1	Lower part fuselage, port, frames 9-10
18	9E	Cut out switch, "generator"	V7K	1	Forward switchboard for starboard console, cockpit

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19	14E	Cut out switch, "storage batteries, on board-airport"	2V-45		Forward switchboard for starboard console, cockpit
20	51M	Relay	TKYe-53PD	1	Relay and fuse box, cockpit frame 11, port side
21	36E	Relay	TKYe-21PD	1	Relay and fuse box, power unit, starboard side, frame 12

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No.	Elec. circuit symbol	Item	Type	Quantity	Location
1	2	3	4	5	6
22	13M	Relay	TKYe-53PD	1	Relay box, fuselage, port side, frames 11-12
23	46S	Relay	TKYe-53PD	1	ditto
24	46E	Voltage circuit breakers	AZP-1MA	1	Starboard side, frames 15-16
25	8E	Fuse	SP-5	1	Relay and fuse box, power unit, starboard side, frame 12
26	12E	Fuse	IP-15	1	Power unit, starboard side, frames 12-13
27	35E	Fuse	SP-5	1	Relay and fuse box, power unit, starboard side, frame 12
28	18E	Relay	TKYe-21PD	1	Relay box, fuselage, port side, frames 11-12
29	17E	Relay	TKYe-(blurred) DT	1	Relay box behind instrument panel, starboard side, frames 6-7
			Page 72		
30	33E	Relay	TKYe-53PD	1	Relay box behind instrument panel, starboard side, frames 6-7

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No.	Elec. circuit symbol	Item	Type	Quantity	Location
1	2	3	4	5	6
31	15E	Socket for measuring generator	48K	1	Power unit, starboard side, fuselage frames 12-13
32	1R	Converter	PO-750A (forward)	1	Below head section of fuselage frames 9-10
33	2R	Converter	PO-750A (after)	1	Below head section of fuselage, frames 10-11
34	15R	Converter	PO-500A	1	Upper equipment hatch, frames 4-5, starboard side
35	5N	Converter	PT-500Ts	1	Upper equipment hatch, frames 4-5
36	40E	Integrating instrument	ISA	1	Starboard, forward section of instrument panel
37	30E	Box for selecting ground supplies	KPA-4	1	Ground equipment
38	34E	Fuse	IP-5	1	Lower part fuselage frames 9-10
39	41E	Shunt	ShSA	1	Below head section fuselage, frames blurred)

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GSR-ST-12000VT Generator-Starter

The type GSR-ST-12000VT starter-generator is a direct current generator with compound excitation.

The starter-generator is designed to start the engine and then for use as a generator to start the engine and then for use as a generator to supply the aircraft electrical network.

The aircraft engine drives the generator when the unit functions in that capacity. The direction of rotation for the rotar is left-handed, that is, counter-clockwise when viewing the starter-generator from the drive side.

In the start mode the GSR-ST-12000VT unit functions entirely from the start-regulate apparatus.

In the generator mode, to maintain voltage constancy, protect from reverse current and provide for stable operation, the GSR-ST-12000VT starter generator functions (words blurred) in conjunction with the following equipment: voltage regulator type RUG-82 with stabilizing transformer TS-9M, condenser KBM-31, and remote rheastat VS-20.

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Fig. 24. Schematic location of main aggregates in the power system and the converters.

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Figure 24. Schematic location of main aggregates in the power system and the converters

1. Converter PO-500A
2. Storage batteries 15STsS-45
3. Voltmeter V-1
4. Integrating Instrument ISA
5. Converter PO-750A
6. Remote resistor VS-20
7. Condensers KBM-31
8. Differential-minimum relay DMR-400D
9. Stabilization transformer TS-9M
10. Voltage regulator RUG-82
11. Generator-starter GSR-ST-12000VT
12. Plug receptacle for taking airport source of supply
13. Converter PT-500Ts

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- differential-minimum relay, type DMR-400D.

The starter-generator is coupled to the aircraft engine through a reducer. When the unit is functioning as a generator cooling is accomplished by passing external air through it. When on the ground, and when used for starting, the GSR-ST-12000VT unit, should function in ambient temperatures of from + 50° C to -60° C.

Principle technical data for the GSR-ST-12000VT:

Rated voltage	28.5 volts
Rated load current	400 amperes
Power (30 volt load)	12000 watts
Operating rotation speed range	4200-9000 rpm
Operating regime	Continuous

When the GSR-ST-12000VT unit is functioning as a generator and is connected to the RUG-82 voltage regulator the output voltage should equal 28.5 ± 0.5 volts.

When using the starter-generator particular attention must be paid to operation of the (illegible).

In normal operation (next three lines illegible)

If dirt is in evidence (words illegible), the ring must be cleaned (next two lines illegible)

If the accumulation cannot be removed, the ring must be cleaned with No. 180-220 sand paper.

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After the ring is cleaned, compressed air should be used to blow away particles.

When the brushes have worn down to 17 millimeters they must be replaced from the set of spare parts.

Storage battery 15STsS-45

Aviation storage batteries, type 15STsS-45, are designed for starting aircraft engines, as well as a reserve source of current in the event the starter-generator GSR-ST-12000VT breaks down. The voltage delivered by a charged 15STsS-45 battery, for a load of 100 amps, should be not less than 21 volts.

Figure 25 shows the storage battery installation.

Since the aircraft storage batteries are not fully recharged in flight, and since some of the charge is dissipated in supplying connected equipment when the engine is cut in, it is necessary to conserve the energy contained in the batteries.

In the event the batteries are kept in the aircraft when the ambient temperature is below 0°C, it is necessary to cut in the battery heater on the ground supply source with a rated voltage of $+27 \pm 10\%$ volts.

Differential-minimum relay DMR-400D

The main purpose of the DMR-400D is to automatically control the cutting out and cutting in of the generator with respect to the aircraft's network.

Figure 25. Storage battery 15STsS-45 installation

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Figure 25. Storage battery 15STsS-45 installation:

1. Holder
2. Storage battery 15STsS-45
3. Strap for securing storage battery to holder
4. Drainage tubing
5. Hatch cover latch
6. Hatch cover
7. Screws for securing holder to hatch cover
8. Cable
9. Heater jacket

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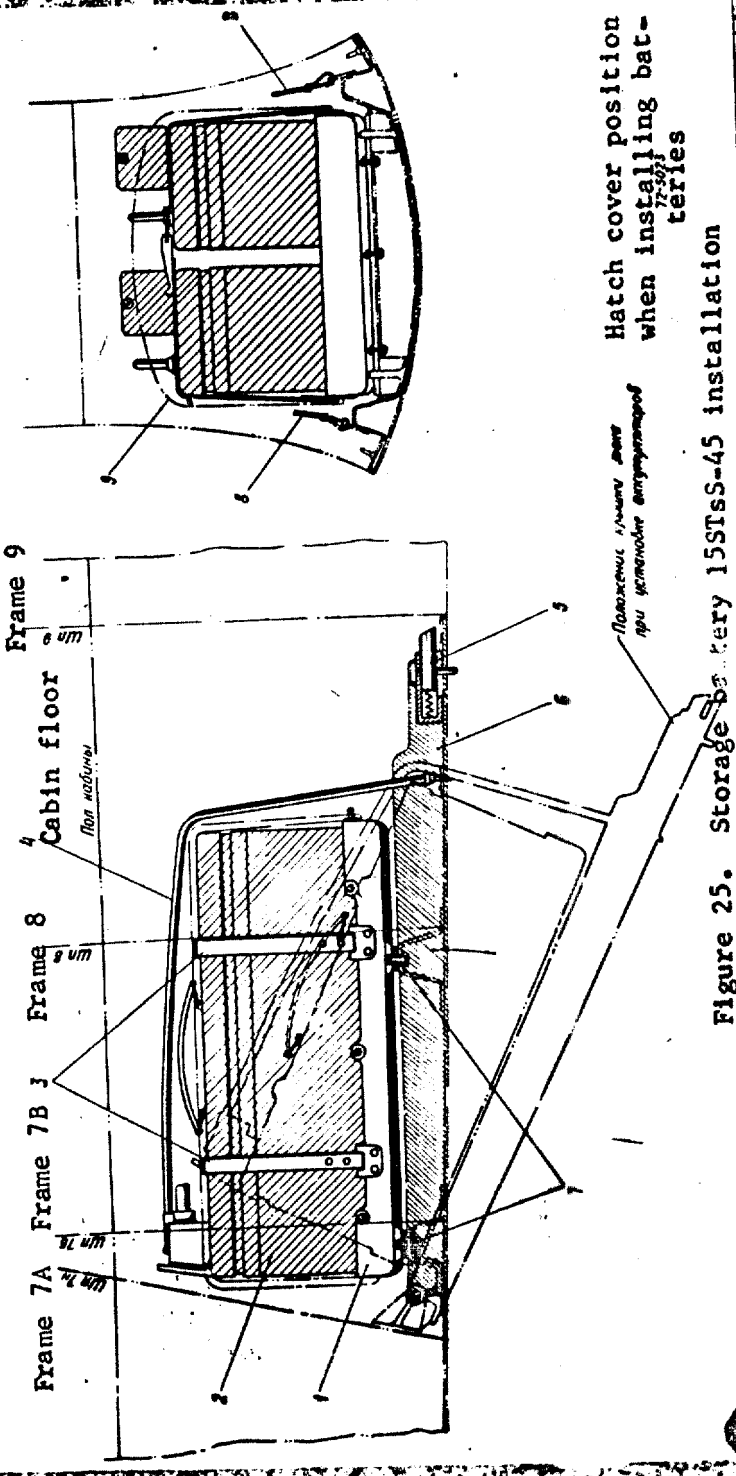

Figure 25. Storage battery 15STsS-45 installation

Рис. 25. Установка аккумулятора 15СТС-45

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The relay performs the following functions:

connects the generator to the network when its voltage exceeds the voltage across the sources of supply previously connected to the aircraft's network by 0.8-0.7 volt;

protects the generator from reverse current, disconnecting it from the aircraft network when the generator voltage falls below that present in the aircraft network and a reverse current of from 15 to 35 amperes flows through the relay;

prevents the generator from cutting in on the aircraft network if the wrong polarity has been connected.

During operation a check should be made for proper connection of the cables to the terminals of the DMR-400D, as well as for correct tightness of the nuts on the DMR-400D terminals.

Voltage regulator RUG-82

The RUG-82 voltage regulator is designed to maintain a constant generator voltage.

Functioning in conjunction with the RUG-82 are:

the stabilization transformer TS-9M;

the remote resistor VS-20, for adjusting generator voltage manually;

the KBM-31 condensers.

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Rated voltage, maintained by the RUG-82 regulator, is equal to 28.5 ± 0.5 volts.

The regulator ensures a stable voltage for changes in generator excitation current within a range of from 2 amperes to 15 amperes.

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Stabilization Transformer TS-9M

The TS-9M transformer is both a current and voltage stabilization transformer and is designed to dampen oscillations as engine load or rpm change.

Condensers KBM-31

KBM-31 condensers are connected to the voltage regulator RUG-82 and differential relay DMR-400D. The condensers serve to reduce noise in the radio equipment arising as a result of generator operation or operation of devices associated with generator operation, (DMR-400D and RUG-82).

Voltmeter V-1

The V-1 voltmeter is connected across the aircraft's network and indicates the voltage in the network when the supply is from the ground source, from the generator, or from the storage batteries.

When the source of supply is disconnected the voltmeter needle should be at zero.

When necessary the needle should be positioned at zero by the set screw.

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Contactors KM-400D and KP-400D

The KM-400D contactors are designed for remote control of connecting and disconnecting the storage batteries.

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The KP-400D contactors are designed to switch the storage batteries from parallel connection (24 volts) to series (48 volts) when starting the engine.

Basic technical data:

rated voltage	27 volts
rated current load, operating	400 amperes
operation	continuous
rated current, coils	0.98 amperes

Box KPA-4

A receptical, ShRA-250 MLK, is installed in the aircraft. Cutting in the airfield supply source is accomplished by means of a cable and plug ShRA-250 MLK and a box KPA-4 which is part of the ground equipment.

Box KPA-4 provides a means for connecting the airfield supply source to the aircraft network and making it impossible to connect it with the wrong polarity. It also provides a means for switching from 24 volts when starting the engine from the airfield supply source.

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Electrical Circuit Operation

When the generator (sym. 1E) begins to operate "+" voltage from the generator is brought to the power cable through one stabilization transformer (7E) as DMR-400D (the differential-minimum relay) functions.

When switch (sym. 9E) closes relay TKYe (blurred) in DMR-400D functions and voltage is passed through the contacts to the winding and contacts of relay TKYe-10B, as

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well as to the winding and contacts of the differential control relay.

When generator voltage value reaches 0.3-0.7 volts in excess of that in the network, the current in the shunt winding of the differential relay creates a flow in the magnetic gap, the direction in accordance with the flow in the permanent magnets.

The relay contacts close and " $\neq$" from the generator is fed to the winding of the DMR-400D contactor. The contactor contacts close and the generator is connected to the network.

When the contactor contacts close relay TKYe-53PD (sym. 46S) and relay TKY3-31PD (36E) function.

The contactor connects the generator to the on-board network through ammeter shunt ShA-2 (sym. 4E). Relay TKYe-53PD (sym. 46S) cuts out the red pilot light "generator off" and supplies power to relays TKYe-24PD (sym. 18E), TKYe-203DT (sym. 17E) and TKYe-53PD (sym. 33E)

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for energizing power users.

When the relay (36E) operates it disconnects the shunt winding of the differential control relay DMR-400D from the "BAT" terminal of DMR-400D and connects it to the " /" terminal of the GSR-ST-12000VT (sym 1E) generator.

In the event of a break in the power cables running from the generator (sym. 1E) to DMR-400D (sym. 2E) current will flow through the shunt winding of the differential control relay and create a magnetic flow, the direction of which is opposite to that of the permanent magnets.

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The differential relay contacts open and current to the contactor windings is cut off.

At the same time, current to the windings of relays symbols 46S and 36E is also cut off; that is, the supply to the power consumers is disconnected (by relay symbols 17E, 18E and 33E) and the pilot light (sym.47S) - "generator on" - on display T-6 is cut in.

Should the voltage in the generator fall below that in the aircraft network, a reverse current is generated in the core of the polarized relay winding which causes the polarized relay to function, cutting off the current to the winding of the contactor in DMR-400D, as well as to the relay (sym. 46S and 36E). The contactor contacts return to the original position (open) and disconnect the generator from the on-board network, while the relay contacts (sym. 46S) energize the red pilot light (sym. 47S) and pick up the supply from the relay windings (sym. 17E, 18E, and 33E) for energizing the power consumers. The reverse current for cutting out the generator is equal to 15 to 35 amperes.

An RUG-82 (sym. 3E) voltage regulator and a TS-9M (sym. 7E) stabilization transformer are used to maintain a constant generator voltage and to dampen oscillations resulting from changes in the load on the engine, or from changes in engine revolutions.

The voltage regulator has an electromagnet, a carbon core and a rheostat for making adjustments.

The carbon core is contained in the shunt winding used for generator excitation and changes its resistance in inverse ratio to the pressure created by the electro-magnet.

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The electromagnet has four windings: operating (l_1), correcting (l_2), compensating (l_3), and parallel operation (l_4) which, in this particular aircraft, is not used.

A remote resistance VS-20 (sym 25E) is connected to the RUG-82 for manually adjusting the voltage.

Increasing the generator voltage results in increasing the current in the electromagnet windings and reducing the pressure on the carbon core.

Increasing the resistance of the core results in decreasing the current in the shunt winding of generator excitation and, accordingly, reducing the voltage across it.

The TS-9M transformer is both a current and a voltage transformer. The transformer has three windings. The TS-9m has no power current winding; its role is played by the power leads which pass through the transformer opening. The primary is a parallel winding and is connected in parallel with the generator excitation winding. The secondary winding is connected in series with the operating winding of the electromagnet of the voltage regulator. The electromotive force induced in it by changes of current in one or the other of the primary windings prevents a change in current in the electromagnet operating winding of the carbon regulator.

The equalizer winding is designed for parallel operation of several generators (not used in this particular aircraft).

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The transformer functions when a change in generator operation occurs (change in engine revolutions, change in load).

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The role of the transformer consists of quenching automatic oscillations resulting from oscillations in voltage and current as the load on the generator changes, and which are accompanied by sharp "blows" on the carbon regulator armature and DMR-400D contactor.

When sharp changes in generator voltage occur there are corresponding changes in the amounts of current in the generator excitation winding, as well as in the voltage in the winding. A change in voltage results in an induced electromotive force in the secondary winding of TS-9M; this, in turn, effects the current strength in the voltage regulator operating winding, momentarily weakening, or reducing, the strength of the electromagnet and there is, accordingly, a dampening of the oscillation in the regulator armature.

A sharp change in generator load current also results in a transformation of the emf in the secondary winding.

Three KBM-31 (sym. 6E) condensers have been installed to reduce interference in the radio receiver.

A plug (sym. 15E) has been connected to shunt ShA-2 for purposes of measuring the current required from the generator and voltmeter V-1 (sym. 16E) is installed for purposes of measuring the voltage. The voltmeter circuit is protected by fuses (sym. 8E).

The aircraft storage batteries 15StsS45 (sym. 10E) are connected to the aircraft network and disconnected from it by means of a switch (sym. 14E) and contactors

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(sym. 19E, 26E).

When the engine is to be started on battery the batteries are switched from parallel to series by contactors KP-400D (sym. 27E, 28E) to obtain 48 volts.

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The aircraft network is, in this case, supplied from storage battery No. 1 only (sym. 10E).

When the switch (sym 14E) is closed a negative voltage is supplied to the contactor (sym. 19E) winding through the normally closed contacts 8-7 in the relay for blocking airfield supply (sym. 13M), the contactor (sym. 19E) operates and cuts storage battery No. 1 into the aircraft network. Simultaneously negative voltage is supplied from storage battery No. 2 to the contactor (sym. 26E) winding for cutting in storage battery No 2 (sym. 10E). This voltage is fed through the switch (sym. 14E) and contacts 4-5 in the relay (sym. 13M). The contactor (sym. 26E) functions and cuts storage battery No. 2 in on the aircraft network.

A receptacle for plug ShRA-250MLK (sym. 13E) is installed in the aircraft for hooking in the airfield supply source.

Connecting the airfield source of supply is done by means of box KPA-4 (sym. 30E), which is part of the ground supply source complex. Three contactors and two relays are installed in the box for selecting the storage batteries (sym. 30E). When the plug for the airfield supply is plugged

in relay (sym. 13M, 18E, 17E and 38E) is cut in for energizing the power consumers through contacts 4-5, 7-8 of the relay (sym. 48S).

When the relay (sym. 13M) functions the circuits for supplying contactor (sym. 19E, 26E) windings are opened and the aircraft storage batteries are disconnected. The open contacts 1-2 (sym. 13M) break the circuit for cutting in DMR-400D (sym. 2E) through the closed contacts of switch symbol 9E. The generator is disconnected from the aircraft network.

When contacts 8-9 in the relay (sym. 13M) are closed negative voltage is fed through the two relays TDE-21 (in box KPA-4) to the windings of the

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two contactors KM-400D which, operating, cut the airfield supply into the aircraft network.

In the event the airfield supply sources are of the wrong polarity relay T(blur)E-210 functions and makes it impossible to connect these sources to the aircraft's network.

Thus, KPA-4 and the relay for blocking the airfield supply (sym. 13M), when the airfield supply is cut in, provide for:

connecting the airfield supply source to the aircraft network;

simultaneously disconnecting the storage batteries and the generator from the aircraft's network;

connecting power consumers;

making it impossible to connect the airfield supply in the event the polarity is incorrect.

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Alternating Current Sources

The AC sources in the aircraft are:

converters PO-750A (sym. 1R and 2R) and converter PO-500A (sym. 15R), which convert the +27 volts direct current into single phase, alternating current at 115 volts and 400 cycles;

converter PT-500Ts (sym. 5N), which converts the +27 volts direct current into three phase alternating current at 36 volts and 400 cycles.

Converter PO-750A (sym. 1R) supplies:

communications radio station RSIU through fuse 8P-5 (sym. 14R) and contacts 7-8 in the relay (sym. 32R);

the automatic radio compass ARK-10, through fuse 8P-5 (sym. 19R) and contacts 13-14 of the relay (sym. 32R);

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the thyratron vibrator PT-56M of the (fuel) consumption meter RTS-16A-4 through fuse SP-5 (sym. 30R) and contacts 13-14 of the relay (sym. 32R);

the ionization fire signal device IS-2MS through fuse SP-5 (sym. 55R) and contacts 13-14 of the relay (sym. 32R);

the DIM-8T transformer through fuse SP-5 (sym. 22Ye) and contacts 13-14 of the relay (sym. 32R).

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Converter PO-750A (sym. 2R) ensures the supply to:

Range-only radar through fuse SP-5 (sym. 29R) and contacts 5-6 of the relay (sym. 28R);

station RV-U through fuse SP-5 (sym. 37R) and contacts 3-2 of the relay (sym. 53R).

In the event converter PO-750A (sym. 1R) breaks down stations RSIU-5G and ARK-10, as well as the consumption meter IS-2MS and DIM-8T are cut via AZS (breaker) (sym. 7R).

The "converter emergency switch" switches to supply from converter PO-750A (sym. 2R), but the supply for the RV-U station and the MRP will be from this same converter only when AZS (sym. 22R) is cut in.

"For PO-750A failure," "RV-U, MRP" to the "RV-U, MRP" position.

Converter PT-500Ts (sym. 2N) supplies the KSI, AGD, VRD-2A block of the range-only radar as well as the VK-53RB (sym. 12N).

Converter PO-500A (sym. 15R) ensures the supply to the ASP-5ND sight through fuse SP-5 (sym. 20R), the infrared viewfinder SIV-52 through fuse SP-5 (sym. 47R) and the electrical launching device EPU-13 of the K-13 system through fuse SP-5 (sym. 14P).

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NOTE: Converters of the PO-750A type (sym. 1R, 2R) when connected in the circuit ensure starting when any device connected and supplied from a given converter is cut in, except for the DIM, the consumption meters and the IS-2MS, which obtain supply when any of the devices requiring alteranting current from converter PO-750A (sym. 1R) cut in.

2. Engine Starting System

General Information

The engine starting system is designed to start the engine either on the ground or in the air, as well as to turn the engine over when cold.

The electrical devices given in the table ensure operation of the engine starting system.

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No.	No. of position in the electrical circuit	Name of item	Type	Quantity	Location
1	2	3	4	5	6
1	1E	Starter-generator	GSR-ST-12000VT	1	Under engine, frame 28
2	4M	Start relay box	KPR-15A	1	Starboard side fuselage, frame 15-16A, lower
3	10E	Storage batteries	15STsS-45	2	Under cockpit floor between frames 7A-9
4	14E	Switch: storage batteries - airfield	2V-45	1	Forward switchboard of starboard console in cockpit
5	1 Ye	Circuit breaker "starting units"	AZS-25	1	Cockpit, switchboard, port console
6	5M	Circuit breaker "pump No. 2"	AZS-5	1	same
7	34K	circuit breaker "generator signal start KLS" (provisional translation)	AZS-5	1	same
8	13K	Circuit breaker "tank pressure signal"	AZO-5	1	same

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9	44E	Contactor	KP-50D	1	Relay box, storage battery hatch, frames 7A-8	
10	42E	Fuse	IP-20	1	same	
11	43E	Fuse	IP-20	1	same	
12	45E	Resistance	SP-0, 3-0.08-0.03	1	same	
			Page 93 87K			
13	42M	Fuse		1	Relay box between frames 15-16, starboard side fuselage	
14	19E	Contactor	KM-400D	1	Contactor box in storage battery recess, frames 9-10	
15	26E	Contactor	KM-400D	1	same	
16	6M	Contactor	KM-50D	1	Contactor block, frames 12-13, starboard side fuselage	
17	8M	Pump, 3rd tank	Aggregate 422	1	Lower part fuselage, frame 18	
18	7M	Filter	F-373T	1	Lower part fuselage, between frames 16-16A, port	

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19	3M	Fuse	IP-10	1	Relay box, starboard side, frames 15-16	
20	1M	Automatic timer	AV7-44-5	1	Starboard side fuselage, frames 15-16A, bottom	

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21	2Ye	Push button, "ground start"	204K	1	Horizontal section of port console near instrument panel	
22	18Ye	Switch"cold turnover engine"	2E-45	1	Switchboard, port console, cockpit	
23	2M	Gasoline pump start	PNR-10-9M	1	Lower part fuselage between frames 20-22	
24	38Ye	Fuse	IP-10	1	Relay box between frames 16-16, starboard side fuselage	
25	39Ye	Fuse	IP-10	1	same	

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26	14Ye	Fuse	3PPN-45	1	same	
27	4Ye	Ignition boil block	KNA-114	2	Engine	
28	3Ye	Spark plug	SPN-43	2	Engine	
29	18S	Pilot light "engine start"	Red	1	T-6 display, instrument panel	
30	41Ye	Fuse	IP-5	1	Relay box between frames 15-16, starboard side fuselage	
31	97M	Box, automatic device for afterburner	KAF-13D	1	Starboard, lower section fuselage, frames 15-16	
32	15Ye	Relay	TKYe-56ND	1	Relay box behind instrument panel, starboard side, frame 6	
33	33Ye	Ignition coil	KNA-114	1	Tail section fuselage between frames 30-31	
34	8Ye	Spark plug, afterburner chamber	SPN-43	1	Engine	
35	38E	Contactor	KM-400D	1	Start contactor box, frames 10-11, under cockpit floor	

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36	46E	Over-voltage circuit breaker	AZP-1MA	1	Starboard side, frames 15-16
37	37E	Contactor	KM-400D	1	Start contactor box, frames 10-11, under cockpit floor
38	5E	Starting resistance	SP-0.05 ohms	1	same
39	51M	Relay	TKYe-53PD	1	Relay box near frame 11 in cockpit

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40	27E	Contactor	KM-400D	1	Box, frames 9-10 under cockpit floor
41	28E	Contactor	KP-400D	1	same
42	6Ye	Fuel valve, electromagnetic	EM5	1	Engine
43	10Ye	Control block	BU-4B	1	Engine
44	32Ye	Electromagnetic valve for fuel make-up	EM2	1	Engine
45	13M	Relay	TKYe-53PD	1	Relay box, port side fuselage between frames 11-12

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46	12Ye	Relay	TKYe-21PD	1	Same
47	30E	Ground supply selector box	KPA-4	1	Airfield supply source cable run
48	13E	Receptacle for connecting airfield supply source	ShRA-250MLK	1	Lower skin fuselage, between frames 9-10
49	31Ye	Circuit breaker "airborne starting"	AZS-10	1	Port console, cockpit

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50	62M	Electromagnetic valve for oxygen make-up	69440S	1	Lower part fuselage, frame 19
51	42Ye	Electromagnetic valve for controlling air by-pass with the hydraulic valves	EM-8	1	Engine
52	29Ye	Circuit breaker "afterburner"	AZS-15	1	Switchboard, port console, cockpit
53	28M	Relay	TKYe-52ND	1	Relay box between frames 15-16A, lower part, starboard side
54	35Ye	Electromagnet for dumping fuel	EM4	1	Engine

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The engine start system consists of a circuit for supplying the units required to start the engine from two storage batteries, 15STs8-45, furnishing 24 or 48 volts.

The starter-generator GSR-ST-12000VT will not, when supplied with 24 volts (the storage batteries connected in parallel) turn the engine turbine over at revolutions for "low gas" operation.

In order to ensure reliable engine start on a start cycle of 7.1 seconds, the storage batteries are automatically switched to series connection and the starter-generator, as well as the other starting units (the block of ignition coils for starting fuel, the starting fuel pump electric motor, the starting fuel valve electromagnet, the make-up fuel valve electromagnet, and the electromagnet for the valve controlling by-pass air with the hydraulic valves), are supplied with the increased voltage.

NOTE: The increased voltage supply to the starter-generator increases the torque on the starter-generator shaft and intensive engine crank-up occurs.

The units used in the starting procedure are switched to supply from the series connected batteries because, on starting, the battery voltage drops considerably (approximately three times).

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A reduced voltage supply (from one battery) results in ignition coil malfunction ("jerky" operation of the interrupter, formation of an electrical arc and burning of the interrupter contacts), reduced flow from the starting fuel pump (which slows the starting process or results in failure to start), non-operation of the valve electromagnets of the valves for starting fuel, make-up fuel, and for by-pass air hydraulic valve control.

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As starter-generator revolutions increase its power demand drops and the voltage of the series connected batteries is restored

In order to protect the starting units from over-voltage (more than 29.5 volts) a relay, RN, is installed in the starting relay box. This relay, when the voltage increases to over 29.5 volts, switches the supply to the units to one battery.

NOTE: The RN relay operates at a voltage of 29.5 volts +0.5 and -1.5 volts, but in order to cause the relay to function at a voltage of 29.5 volts a resistance R_n has been inserted in the relay winding circuit.

The engine start system, consisting of the circuit for supplying the units required to start the engine with 24 or 48 volts, permits:

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starting the engine from battery on the ground;

starting the engine from the airfield supply source;

starting the engine in the air;

turning the engine over cold.

Operation of the Electrical System

(a) Starting the engines from on-board storage batteries is accomplished directly from the starter-generator, which obtains its supply from the batteries (sym. 10E).

The starting procedure requires turning on of switch (sym. 14E) and circuit breakers (sym. 1Ye, 29Ye, 5M, 34K, 13K). The throttle is set in the "low gas" position. The oxygen make-up selector switch (sym. 42M) and the conservation selector switch (sym. 14Ye) are set in the operate position.

When the switch (sym. 14E) is closed the contactors (sym. 19E, 26E) function, connecting the storage batteries (in parallel) to the aircraft's electrical system.

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When the AZS (sym. 5M) is cut in the contactor (sym. 5M) which connects the electric motor for the pump on the fuel tank in use (sym. 8M) through filter (sym. 7M) to the circuit operates.

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When the AZS (sym. 29Ye) is cut in "positive" voltage is fed to the relay winding (sym. 28M) through contacts 2-1(one number blurred) of the relay (sym. 38M, 29M).

The relay (sym. 28M) functions, contacts 2-1 break the supply circuit to the terminals for the hydro-electric valve (sym. 153M) from the power unit bus through fuse symbol 154M and contacts 6-5 close the circuit supplying terminal 2 of the hydro-electric valve plug (sym. 163M) from the AZS (sym. 29Ye).

The engine nozzle valve is switched to the after burner position.

The supply, accordingly, is fed directly from the No. 1 (sym. 10E) storage battery, through fuse symbol 12E, contacts 3-1 of contactor symbol 44E and terminals 14, 38, 18 and 35 of the plug for the start relay box (sym. 4M) to:

contact 9 of relay R6 through contacts 1-2 of relay R4;

contact 3 of relay R8;

contact 5 of relays R3 and R4;

contact 3 of relays R14 and 8;

contact 2 of relay R10.

When AZS (sym. 1A) is turned on the aircraft network supply is fed to contact 3 of relay (number illegigle) in the start relay box (sym. 4M) through terminal (illegible) of the box connector and to contacts 4-5, 2-1 of relay

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OSh, while power is supplied, through fuse symbol 3M, to:

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contact 3 of relays R6 and R7 and contact 6 of relay R5 respectively via terminals 37 and 29 of the plug for the start relay box (sym. 4M);

microswitches 1 and 2, contacts 2 and 5 of relay A3, contact 3 of relay A4 via terminal 10 of the plug for the automatic timer (sym. 1M), as well as the start button (sym, 2Ye) via contacts 0-N3 of microswitch 2 and terminal 7 of the plug for the automatic timer (sym. 1M).

The start button (sym. 2Ye) is pressed. The following must be connected in the circuit when the start button is pressed:

main fuel ignition coil (sym. 4Ye);

the pilot light indicating ignition on (sym. 18S);

the electric motor for the pump providing starting fuel (sym. 2M);

the electric motor for the automatic timer (sym. 1M);

afterburner fuel ignition coil (sym. 83Ye).

The main fuel ignition coil (sym. 4Ye) obtains its supply from a circuit which includes the start button (sym. 2Ye), contacts 2-1 of relay G (sym. 4M), contacts 1-2 of relay R11 (sym. 4M), switch contacts (sym. 18Ye), contacts 4-5 of relay 3V (sym. M), contacts 4-5 of relay R5 (sym. 4M), the winding of relay Z (sym. 4M). Relay Z,

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functioning, closes its contacts 3-2, 5-6 and supplies "plus" from the battery to the ignition coil (sym. 4Ye) via a fuse (sym. 42E), contacts 2-1 of the contactor (sym. 44E) and then two more fuses (sym. 39Ye and 32Ye) and the contacts of switch symbol 14Ye.

The pilot light (sym. 18S) indicating ignition on is connected through a circuit consisting of a fuse (sym. 41Ye), contacts 2-1 of relay KR (sym 97M), and contacts 13-14 of relay symbol 15Ye..

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The after burner fuel ignition coil (sym. 33Ye) is connected through a cricuit consisting of a fuse (sym. 41Ye), contacts 2-1 of relay KR (sym 97M), contacts 5-4 of relay R7 (sym. 4M), and contacts 3-2 of relay R9 (sym 4M). Relay R9 is cut in through contacts of switch symbol 18Ye.

The spark plug for afterburner fuel ignition is prechecked (prior to feeding afterburner fuel).

The electric motor for the pump which upplies starting fuel (sym. 2M) is energized by a circuit which consists of the start button (sym. 2Ye), contacts 2-1 of relay G (sym. 4M), contacts 1-2 of relay R11)sym. 4M), switch contacts (sym. 13Ye), contacts 4-3 of relay 3V (sym. 4M), and the winding of relay R14. Relay R14 (sym. 4M) functions, closing contacts 3-2 and 6-5 and connecting the on-board network to the electric motor for the pump supplying starting fuel. The motor begins to run.

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The automatic timer electric motor (sym. 1M) is energized by a circuit which consists of the push button (sym. 2Ye), contacts 2-1 of relay G (sym. 4M), contacts 1-2 of relay R11 (sym. 4M), terminal 12 and the winding of relay A1 (sym. 1M). The relay operates and current is supplied via contacts 9-8 to the winding of relay A4 (sym. 1M) and via contacts 4-5 of relay A2 (sym. 1M). Relay A4 functions and via contacts 3-2 feeds "+" from the aircraft's network through the AZS (sym. 1Ye) and a fuse (sym. 3M). The electric motor begins to rotate the automatic timer cam, closing the corresponding microswitch in the start circuit. The development of the start cycle program begins.

Current is supplied simultaneously to microswitches 3, 4, 5, 6, and 7 so that relay A3 functions and closes contacts 2-3, 5-6 (the supply for the winding of relay A3 is through contacts 5-6 of relay A1). The circuit consisting of microswitches 3, 4, 5, 6 and 7 is ready for operation.

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When the start button (sym. 2Ye) is pressed relay RV (sym. 4M) is also cut in via contacts 2-1 of relay G.

When relay RV functions contacts 3-2 cut in relay R16 which, in turn, through contacts 1-2, opens the circuit supplying the winding of relay RN.

The development of the start cycle program for the automatic timer (sym. 1M) takes place in the following sequence.

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After an interval of 1.4 seconds microswitch 1 closes and delivers, through its contacts O-NR, "+" to the winding of relay A4, to the winding of relay A1 via contacts 5-4, relay A2 and contacts 8-9 of relay A1 and to the winding of relay A3 through contacts 5-6 of relay A1. Relay A1 picks up and the start button (sym. 2Ye) can be released.

The automatic timer electric motor, as well as microswitches 3, 4, 5, 6 and 7 are now supplied when the start button is released. "+" is also supplied to the winding of relay R2 through the circuit breaker, an overvoltage type AZP-1MA (sym. 46E).

Relay R2 functions and when its contacts open the circuit which connects the generator-starter (sym. 1E) to the aircraft's internal system is broken.

After an interval of 1.6 seconds microswitches 6 and 7 function. Microswitch 6 supplies "+" to the winding of relay R8 through its contacts O-NZ, through contacts 5-4 to relay R3 and through contacts 9-8 to relay R4. Relay R8 functions and through contacts 3-2 supplies current to the electromagnet (sym. 35Ye) for the fuel dump valve.

Microswitch 7, through contacts O=NR, supplies "+" to the winding of relay R4. Relay R4 functions and, through contacts 5-6, cuts in the electromagne (sym. 42Ye) for the valve which controls air by-pass through the hydraulic valve system.

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After an interval of 1.9 seconds microswitch 2 functions and through contacts O-NR supplies "+" to the contactor winding (sym. 38E) and relay Sh (sym. 4M), and through contacts 2-3 to relay A1 (sym. 1M).

The contactor (sym. 38E) functions and supplies "+" from storage battery number 2 (sym. 10E) to the series winding of the starter-generator (sym. 1E) through a resistance (sym. 5E).

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The starter-generator is connected through the resistance (sym. 5E) so that engine turbine turnover will be smooth.

Relay Sh (sym.14M) functions, contacts 1-2 disconnect the shunt winding of the starter-generator (sym.1E) from the RUG-32 (sym.3E), while contacts 3-2 supply "+" from the internal network to the shunt winding of the generator (sym. 1E) through the AZS (sym. 1YE) and contacts 4-6 and 2-1 of relay OSh (sym. 4M).

The starter-generator (sym. 1E) receives mixed excitation:

after an interval of 4.1 seconds microswitch 3 functions and contacts O-NR deliver "+" to the windings of the contactor (sym. 37E) and the relay (sym. 51M). The contactor (sym. 37E) is cut in, blocking the resistance (sym. 5E) and increasing the excitation current in the series winding of the starter-generator. The relay (sym. 51M) functions, contacts 7-8 cut out winding L_R, the RUG-32 voltage regulator coil (sym. 3Ye), (so that when the storage batteries are switched to 48 volts RUG-32 does not burn out), while contacts 5-6 ready the circuit for switchover (via KNA-4, sym. 30E) to 48 volts when starting the engine from the airfield supply source.

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After an interval of 7.1 seconds microswitch 5 functions and contacts O-NR supply "+" to the winding of relay R10 (sym. 4M) through the switch contacts (sym. 18Ye) and contacts 5-6 of relay Sh, as well as to contact 5 of relay R10. Relay R10 functions, supplying current through contacts 5-6 to the contactor windings (sym. 27E, 28E) and to the winding of relay R7 through contacts 1-2 of relay R3 (sym. 4M). Contacts 2-3 serve to cut in the electromagnet (sym. 6Ye) for starting fuel. Contactors, symbols 27E and 28E, operate and switch the storage batteries (sym. 10E) to series connection, that is to 48 volts. When relay R7 functions its contacts 3-2 supply current to the selector switch ST and VDT of the BU-4B control block (sym. 10Ye), while contacts 5-4 break the circuit for prechecking the plug for igniting afterburning fuel (sym. 33Ye).

The VDT contacts furnish the "+" to the winding of relay R6 (sym. 4M). Relay R6 functions and its contacts 5-6 close a supplemental circuit to supply the electromagnet (sym. 42Ye) for the valve which controls by-pass air with the hydraulic valve system (in parallel with contacts 5-6 of relay R4), while contacts 3-2 feed "+" to the winding of the contactor (sym. 44E) through contacts 2-3 of relay R12, contacts 2-1 of relay R15,

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contacts 11-12 of relay R14 in the start relay box (sym. 4M) and through contacts 2-1 of relay symbol 12Ye.

The contactor (sym. 44E) functions and contacts 3-1 connect the ignition coil (sym. 4Ye) to 48 volts over a circuit consisting of contacts

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3-2 and 5-6 of relay Z (sym. 4M), fuses (sym. 38Ye, 39Ye) and contacts of the selector switch (sym. 14Ye).

Selector switch ST operates when revolutions correspond to 32% of rotor revolutions at high pressure (3500-38-- rpm). Selector switch VDT operates when revolutions correspond to 48% of rotor revolutions at high pressure (5300-5800 rpm).

If the engine turns up to revolutions for "low gas" (3500-3800 rpm) sooner than the automatic timing program (sym. 1M) evolves, selector switch ST supplies "+" to the winding of relay R5 (sym. 4M). Relay R5 functions and contacts 2-1 break the negative circuit of relay A1 (sym. 1M). Relay A1 is dead, its contacts 5-6 open, and the supply circuit to the winding of relay A3 opens. Relay A3 goes dead in turn and the opening of contacts 2-3 and 5-6 break the circuit supplying microswitches 3, 4, 5, 6, and 7. The automatic timer (sym. 1M) curtails program development, despite the fact that its electric motor will run until such

time as microswitch 1 contacts O-NZ are no longer closed and the circuit supplying the winding of relay A4 is no longer broken.

Contacts 6-5 of relay R5 supply "+" to the winding of relay Z. Relay Z functions and its contacts 3-2 and 5-6 connect the ignition coil (sym. 4Ye).

When an rpm rate is reached which corresponds to 48% of rotor revolutions at high pressure (5300-5800 rpm) the VDT selector switch functions and the winding of relay R6 receives no current. The relay drops its contacts 3-2 and 5-6 and the circuit which supplies the electromagnets (sym. 42Ye, 32Ye) and the contactors (sym. 44E) is opened.

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After an interval of 12.6 seconds microswitch 4 functions and contactors NZ-0 deliver "+" to the winding of relay SSh and R11 in the box (sym. 4M).

When relay SSh functions the supplementary resistance R_{sh} is unblocked and is connected to the starter-generator (sym. 1E) shunt winding circuit. The current in the shunt winding is decreased 3 to 4 times. The starter-generator (sym 1E) revolutions increase.

Relay R11 blocks itself through its contacts 6-5, while contacts 2-1 interrupt the circuit which supplies the winding of relay R8 (sym.4M). Within 0.5 second after its supply is cut off relay R8, through contacts 3-2, breaks the circuit supplying the winding of relay R10. (TN: Maybe relay R16). Relay R16 opens contacts 1-2 and connects relay Rn to the ignition coil (sym. 4Ye).

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With the appearance of from 26.5 to 29.5 volts across the ignition coils, relay Rn functions, contacts 2-3 close and " +" is supplied to the winding of relay R12 (sym. 4M). Relay R12, self-blocking by contacts 2-1, with contacts 2-3 interrupts the supply circuit to the contactor winding (sym. 44E). The contactor drops contacts 2-1 and the ignition coil circuit is connected to the supply from a single storage battery, Number 1 (sym. 10E).

NOTE: 1. If the voltage across the ignition coils is less than 26.5-29.5 volts, supply for the coils will be furnished from the series-connected storage batteries to time 25.3 seconds; that is, when microswitch 4 functions;

2. If the ignition coils obtain a supply from one storage battery, then at the time to start the engine low voltage is fed to the

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ignition coils (i.e., the storage battery voltage at start time is quite low) which would result in the interrupter contacts sticking;

microswitch 6 returns to its initial position in 16.6 seconds and opens the supply circuit to the winding of relay R8. Relay R8 drops contacts 3-2, breaking the electromagnet (sym. 35Ye) circuit for the fuel dump value;

microswitch 4 returns to its original position in 25.3 seconds and contacts 0-NR supply "+" to the winding of relay R15. Relay R15 functions and, through contacts 2-1,

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opens the circuit supplying the contactor (sym. 44E) winding. Contacts 1-2 in the contactor (sym. 44E) open and switch the ignition coil (sym. 4Ye) supply from storage battery Number 1 (sym. 10E); that is, storage battery voltage has been restored;

microswitch 7 returns to the original position in 25.6 seconds, opening the supply circuit to the winding of relay R4 which, in turn, opens, through contacts 1-2, the circuit supplying the electromagnet (sym 82Ye) of the make-up fuel value, and opening the supply circuit, with contacts 5-6, to the electromagnet (sym. 42Ye) of the control value for by-pass air by hydraulic values.

NOTE: The electromagnet (sym. 42Ye) continues to receive a supply from contacts 5-6 in relay R6 (sym. 4M) until such time as the relay winding is deenergized by contacts in transfer switch VDT;

microswitch 3 returns to the original position in 42.0 seconds and breaks the circuit supplying the contactor (sym. 87E) winding, once again cutting in the supply to the series winding of the starter-generator (sym. 1E)

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and resistance (sym. 5E), as well as opening the circuit supplying the winding of the relay (sym. 51M) which connects the starter-generator to RUG-82 (sym.3E);

microswitch 2 returns to the original position in 42.7 seconds and closes the

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circuit to the start button (sym. 2Ye);

microswitch 5 returns to its original position in 43.4 seconds and opens the circuit supplying the winding of relay R10 (sym. 4M). Contacts 5-6 in relay R10 provide a supply circuit for the winding of relay R7 and the contactors (sym. 27E, 28E). Storage batteries numbers 1 and 2 (sym. 10E) are switched from series to parallel connection;

in 44 seconds microswitch 1, through contacts 0-NR, opens the circuit supplying the winding of relay A4. Relay A4 drops contacts 3-2, breaking the circuit supplying the L-2R motor. Motor L-2R, in the automatic timer AV7-44-5 (sym. 1M), stops. The start program sequence is terminated.

NOTE: If, for some reason, the starting procedure is interrupted and a new attempt is made to start the engine, the automatic timer motor will continue the program to its termination and it will then be possible to start the engine (in 42.7 seconds microswitch 2 functions and supplies the start button).

(b) Starting the engine from the airfield source of supply is similar to that program used in starting the engine from the aircraft's storage batteries.

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The difference is that when the airfield's power supply is plugged in the starter-generator and the aircraft's electrical system obtain their

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supplies from the airfield's source. When this source is plugged in the changeover to the airfield's storage battery takes place with the functioning of contactor KP-400D, installed in box KPA-4 (sym. 30E) of the ground supply.

Supply is furnished to the winding of contactor KP-400D after the contactors (sym. 27E, 28E) have functioned through contacts 6-5 of the relay (sym. 51M) and the plug for hooking up the airfield supply source ShRA-250 MLK (sym. 13E).

(c) Starting the engine when airborne is accomplished by cutting in the AZS-10 (sym. 31Ye).

When the AZS (sym. 31Ye) is cut in relay "3V" in the box (sym. 4M) operates and, through contacts 6-5, supplies the winding of relay "3".

A positive voltage is simultaneously supplied to the oxygen make-up value (sym. 63M) through contacts 3-2 of relay 3V and to the winding of relay R10 through contacts 9-8 of relay 3V. Relay R10 operates and, through its contacts 3-2, supplies the start fuel valve (sym. 6Ye).

Relay "3", operating, furnishes a positive supply through its contacts 3-2 and 5-6 to:

ignition coil KNA-114 (sym. 4Ye) and the pilot light for signalling ignition on (sym. 18S);

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the winding of relay R14, which functions and, through its contacts 3-2 and 5-6, supplies power to the start pump PNR-10-9M (sym. 2M) motor.

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3. Engine afterburner system

General information

The system in designed to cut in the afterburner regime in order to increase engine thrust.

System operation is carried out with the electrical devices shown in the table.

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No. 1	Symbol 2	Item 3	Type 4	Quantity 5	Location 6
1	29Ye	"afterburner" circuit breaker	AZS-15	1	Electrical switchboard, port console
2	134M	Inertia fuse	IP-3	1	Power unit, starboard side, frames 12-13
3	145M	Switch "emergency jet control"	87K	1	Port console, cockpit
4	34Ye	Terminal switch for hydraulic (blurred)	-	1	Engine
5	10Ye	Control block	RU-4Ye	1	Engine
6	7Ye	Control panel	PURT-10	1	Engine, frame 9 (tentative)
7	97M	Afterburner automata box	(blurred)	1	(Blurred)
		Page 116			
8	153M	Hydro-electric value	GA-164M	1	Tail section fuselage between frames 32-33, upper, starboard
9	37M	Relay	TKYe53PD	1	Relay box, frames 15-16A, starboard side, lower
10	38M	Relay	TKYe52PD	1	Same
11	28M	Relay	TKYe52PD	1	Same
12	151M	Signal presentation box	KVS-1	1	Starboard, lower section of fuselage between frames 14 and 15

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No. 1	Symbol 2	Item 3	Type 4	Quantity 5	Location 6
13	43Ye	Electromagnetic value for additional fuel cleansing	-	1	Engine
14	9Ye	Terminal switch for pump NR-22	-	1	Engine
15	126M	Relay	TKYe53PD	1	Relay box, cockpit, frame 11
16	5Ye	Carburetor electromagnet	-	2	Engine
17	11Ye	Electromagnetic value for pump NR-22F	-	1	Engine, frames 26-27
18	30Ye	Pilot light "afterburner"	Green	1	Display T-6, instrument panel, starboard

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19	14Ye	Transfer switch	EPPN-45	1	Relay box between frames 15 and 16, starboard side fuselage
20	152M	Feedback transmitter	DOS-1A	1	Engine
21	44Ye	Resistor-type transmitter	DR-3A	1	Engine
22	45Ye	Rheostat	R-1	1	Engine
23	33Ye	Afterburner fuel ignition coil	KNA-114	1	Engine
24	29M	Relay	TKYe21PD	1	Relay box, frames 15-16A, starboard side, lower

NOTE: Afterburner automata box KAF-13D contains relays Z, U, F2, U1, V, N, S. D, Ye, F, KR, RV1, RV2, RV3, RV4 and slots Ya, A, D, G, V, Ye, I.

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Afterburner operation

Cutting in the afterburner is done by setting the engine control lever (RUD) to the "minimum afterburner" stop. However, afterburner cut-in will take place only after operation of the units for interlocking the afterburner with respect to engine turnover (the terminal switch for the hydraulic decelerator and transfer switch BFO), that is, after the engine is operating at the number of revolutions selected as the condition for stable engine operation with the afterburner. The dogs of the transfer switches, BFO-2 and BFO-1, in control block BU-4B are set corresponding to 60% and 65% of high pressure rotor revolutions, while the terminal switch for the hydraulic decelerator of regulator pump NR-21F is set for 98% of low pressure rotor revolutions.

When the RUD is moved forward 68° with respect to the limb on control panel PURT-1F the panel transfer switch PK operates and this prepares the circuit for energizing relay "Z" in the KAF-13D afterburner automata box.

When an engine rpm is reached which matches that for closing the terminal switch and switch BFO-1 in block BU-4B, power is fed to the winding of relay "Z".

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which, operating, blocks the terminal switch of the hydraulic decelerator and switch BFO-1, as well as to the relay winding (sym. 38M). Relay symbol 38M operates and its contacts 5-6 ensure that the relay will pick itself up through the closed contacts of transfer switch BFO-2.

Contacts 2-1 in the relay (sym. 38M) function at the same time. The relay (sym. 28M) is disconnected, closes contacts 2-1, and opens contacts 6-5.

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The hydraulicelectric valve (sym. 15M) will switch itself to the "maximum" position.

When the engine control lever is set to the "minimum afterburner" stop (73° on the limb on panel PURT-1F) transfer switch BFS (flaps for blocking the afterburner) in PURT-1F and relay F_1 in KAF-13D function.

When relay N functions the electromagnetic valves for the carburetor and the KNA-114 ignition coil for afterburner fuel are cut in. When operating fuel at rated pressure is obtained in the NR-22F pump regulator the terminal switch for pump NR-22F cuts out the supply to the winding of relay N and, at the same time, cuts out both electromagnetic valves for the carburetor and for the afterburner fuel ignition coil.

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Relay F_2, operating, breaks the circuit to terminal 3 of the plug for hydraulicelectric valve GA-164M and the supply circuit to terminal 2 of the plug for GA-164M is closed. Relay ye also cuts in and this relay, in turn, connects the hydraulicelectric valve GA-164M into the follow-up system consisting of rheostat R-1, polarized relay RPS-5 and transmitters DOS-1A and DR-3A.

The principle of operation of the follow-up system is as follows. The shaft of transmitter DR-3A is rigidly coupled to the shaft of the PURT-1F aggregate and is rotated by the engine control lever and sets in motion the sliding contact of the resistance-type-transmitter DR-3A which, until this time, has been at a stop suitably varying the relationship of the resistances contained in the bridge arm.

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The resultant unbalancing of the bridge activates the sensitive, polarized relay RPS-5, furnishing a supply to the winding of relay a and b in KVS-1.

Relay a and b closes the supply circuit to the GA-164M valve. Value GA-164M opens the intake for the hydraulic fluid of one or the other of the cylinders. The piston, as well as the sliding contact of transmitter DOS-1A, move until such time as the bridge is balanced. When the bridge is balanced the current falls to a value which is less than the sensitivity current for RPS-5 and the hydraulic-electric valve GA-164M is cut out.

When the RUD is set at the "minimum afterburner" stop, thanks to a previously set

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mismatch of DOS-1A and DR-3A, a current flows in the winding of polarized relay RPS-5, contacts Ya and L close, cutting in relay b in KVS-1. When relay b functions a voltage is fed to the number Z terminal of GA-164M. The flaps move from the initial "maximum" position to the "minimum afterburner" position.

The flaps remain in the "minimum afterburner" position during the period of movement of the RUD forward to the 78° position on the limb of the PURT-1F.

This is ensured by the follow-up system being cut in prior to the initial movement of the DR-3A slide.

For each successive movement of the RUD ahead to 108° on the PURT-1F limb a mismatch will occur in the follow-up system and a current will flow in the winding of the polarized relay (until balance is established), contacts Ya and L will close, and relay b in KVS-1 cuts in. Relay b, functioning,

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supplies a voltage to terminal 2 of the plug for the hydraulic-electric valve GA-164M. The flaps smoothly increase their diameter to "full afterburner."

During the course of moving the RUD forward from 108° to 112° on the limb ("full afterburner"), the flaps retain "full afterburner" diameter as a result of the DR-3A slide-being in the fixed resistance section.

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When the RUD is moved in the opposite direction (inward) flap movement takes place in a manner similar to that described above, but in the section from 108° to 78° on the graduated dial of the PURT-1F a mismatch occurs in the follow-up system, with the result that current flows in the winding of polarized relay RPS-5, but in the opposite direction. Contacts Ya and P in this relay close, cutting in relay a in the KVS-1. When relay a functions a supply is provided for the relay winding (sym. 37M). The Relay (sym. 37M) operates, contacts 2-3, close, and current is supplied to terminal 3 of the hydraulic-electric valve, GA-164M plug. This permits the flow of the hydraulic fluid into the other cylinder. The piston, along with the DOS-1A transmitter slide, move in the opposite direction. The flaps smoothly reduce the diameter to "minimum afterburner."

Contacts 5-6 and 8-9 in the relay (sym. 37M) close at the same time. Make-up for the electromagnet of the afterburner fuel pump is provided and the process of disconnecting relay F2 is blocked (in the event the engine control level is abruptly moved to a position less than 73° on the limb of the PURT-1F) despite the fact that no current flows in the F1 relay winding and the relay has dropped its contacts.

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In the event of a failure of the follow-up system the emergency control for engine nozzle flaps can be used. The switch marked "emergency nozzle control" is set in the closed position when this procedure is used.

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Relay v in the KAF-13D operates. If the RUD is in the "full afterburner" position (100° on the PURT-1F limb) the flaps will be set for "maximum" diameter. Afterburner operation is cut out. If the RUD is beyond the "full afterburner" position (from 100° to 112°) the flaps will be set for "full afterburner" diameter.

Control of engine operating conditions with nozzles satisfactory for all conditions, anticipates a delay (in time) of the opening of the jet nozzle flaps and delivery of afterburner fuel. The delay in the change in the diameter of the flaps takes place between RUD positions for "minimum afterburner" and "full afterburner" (from 73° to 108° on the scale), and, in the event emergency control is used, between the "full afterburner" position and the stop (from 108° to 112° on the scale).

The time delay in the opening of the flaps is needed in order to avoid the possibility of a drop in R4 pressure when the afterburner is cut in. The delay can be set for 0, 0.5, 1.0, 1.5 or 2 seconds. These delays are provided for by time-delay relays RV, RV_2, RV_3, RV_4; relays "c" and "d" and also by proper setting of lock switches A, B, V, G, D, and Ye in the KAF-13D box. [T.N.-"lock switch" is an arbitrary translation of the Russian word, shlits, normally meaning "spline". The part is not described but later text indicates it is a two-position open-closeswitching device. The Russian word implies a slotted mechanism, possibly L-shaped or U-shaped.]

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The time delay, for flaps, as well as for fuel, is provided for only when no current flows in the time relay windings. This is accomplished by opening the normally closed contacts in relay F1.

Electrical circuit operation

When the RUD is moved forward to the 68° mark on the limb on the control panel, PURT-1F (sym. 7Ye), transfer switch PK on the panel operates, readying the circuit which cuts in relay Z in KAF-13D (sym. 97M). When the engine reaches rpm for closing terminal switch BFO-1 (transfer switch BFO-2 is already closed) in block BU-4B (sym 10Ye), current from the aircraft network is supplied to the winding of relay Z through the "afterburner" AZS (circuit breaker) (sym. 29Ye), to transfer switch BFO-1, to the contacts of terminal switch for hydraulic decelerator (sym. 34Ye) and transfer switch PK. Relay Z operates and, with its contacts 2-3, blocks the terminal switch for the hydraulic decelerator and transfer switch BFO-1.

Current is provided to the relay winding (sym. 38M) through the BFO-1 contacts as well. The relay (sym. 38M) operates and contacts 1-2 break the supply circuit to the winding of relay symbol 28M. Contacts 5-6 are interlocked through transfer switch BFO-2. The relay (sym 28M) goes dead and contacts 5-6 break the supply circuit to terminal 2 of the hydraulic-electric valve GA-164M (sym. 153M), while contacts 1-2 supply current to terminal 3 of this same valve through contacts 5-4 of relay F2 in the KAF-13D (97M).

The flaps will move from the "afterburner" position to the "maximum" position.

When the RUD is set on "maximum afterburner" stop, transfer switch(blur) on PURT-1F operates. Current is fed to the winding of relay F_1 through AZS

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"afterburner" contacts 5-6 of relay "Z", contacts 4-5 of transfer switch(blur) and contacts 4-5 of relay (blur). Relay F_1 operates and feeds current

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to the electromagnet for the valve of pump NR-22F (sym. 11Ye) and the pilot light which indicates that the afterburner is cut in (sym. 30Ye) through the contacts of lock switch Ye and contacts 7-8 of relay KR in box KAF-13D (sym. 97M), as well as to the winding of relay F2 through the contacts of lock switch D in KAF-13D (sym. 97M) and to the winding of relay N through contacts 1-2 of the terminal switch for pump NR-22F (sym. 9Ye), as well as to the winding of the relay (sym. 29M) through the contacts of lock switch Ye in KAF-13D (sym. 97M) and normally closed contacts 7-8 of relay KR. The relay (sym. 29M) operates and, with contacts 2-1, once again breaks the circuit supplying the relay winding (sym. 28M).

Relay N in KAF-13D functions and contacts 2-3 and 5-6 provide the supply path from the aircraft network through the AZS "afterburner" (sym. 29Ye) to the electromagnetic valves for the carburetors (sym. 5Ye) and the ignition coil KNA-114 (sym. 33Ye) through the transfer switch (sym. 14Ye) contacts.

When operating fuel at rated pressure is obtained in the pump regulator NR-22F, the terminal switch (sym. 9Ye) opens the supply circuit to the winding of relay N, both carburetor electromagnetic valves (sym. 5Ye) and the ignition coil (sym. 33Ye) are disconnected.

Relay F2, operating, breaks the circuit supplying terminal 3 of the hydraulic-electric valve GA-164M (sym. 153M) through contacts 5-4, with contacts 2-3 closing the circuit supplying the winding of relay "Ye" through contacts 8-7 of relay v. Relay "Ye" functions and connects, through contacts

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5-6, the follow-up system to the circuit supplying terminal 2 of the plug for the hydraulic-electric valve GA-164M (sym. 153M).

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With the RUD against the "minimum afterburner" stop, and because of the previously assigned mismatch between transmitters DOS-1A (sym. 152M) and DR-3A (sym. 44Ye) a current flows in the winding of polarized relay RPS-5 in the signal distribution box (sym. 151M). Contacts Ya and L in this relay close, energizing relay b in the KVS-1 (sym. 151M).

Relay b operates, supplying current to terminal 2 of valve GA-164M (sym. 153M).

The flaps move from the initial position "maximum" to the "minimum afterburner" position.

The flaps remain in the "minimum afterburner" positon when the RUD is moved forward to the 78° mark. As the RUD is moved further forward, to the 108° mark a mismatch occurs in the follow-up system and a current flows in the winding of relay RPS-5 (until such time as the bridge in the follow-up system is balanced) and contacts Ya and L close, cutting in relay b in the KVS-1 (sym. 151M). When relay b operates it closes its contacts 3-2 and a voltage is supplied to terminal 2 of the plug for the GA-164M (sym. 153M). The flaps increase their diameter to "full afterburner".

As the RUD is moved from 108° to 112° on the PURT-1F (sym. 7Ye) scale the flaps retain the "full afterburner" diameter because the DR-3A (sym. 44Ye) slide moves onto the fixed resistance section.

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If the RUD is moved backward into the section between 108° and 78° on the PURT-1F (sym. 7Ye) scale, a mismatch occurs in the follow-up system such that a current flows in the winding of relay RPS-5 in the opposite direction. Contacts L and P of this relay close, providing a supply to the winding of relay a in the KVS-1 (sym. 151M). When relay a functions its contacts 3-2 close and complete the circuit from the aircraft network to the winding of the relay (sym. 37M) via the "afterburner" AZS (sym. 29Ye).

When the relay (sym. 37M) operates a supply is provided to terminal 3 of the GA-164M (sym. 153M) plug. The supply circuit to terminal 2 of the GA-164M (sym. 153M) is broken by contacts 3-2 of relay b. The flaps reduce their diameter to "minimum afterburner" and remain in this position until the 73° mark on the scale of the PURT-1F.

With further movement of the RUD the flaps take the "maximum" position.

At revolutions corresponding to 65% of high pressure rotor revolutions transfer switch BFO-1 opens its contacts, but the relay (sym. 38M) is self-supplied through the contacts of the BFO-2 transfer swtich. At revolutions corresponding to 60% of high pressure rotor revolutions the contacts of the BFO-2 transfer switch open and no current flows in the relay winding (sym. 38M). The relay (sym. 28M) is energized by way

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of contacts in relay symbol 38M and relay symbol 29M. Contacts 2-1 open relay symbol 28M, but its contacts 6-5 cut in the supply to terminals 3 and 2 respectively of the hydraulic-electric valve (sym. 153M) plug. The flaps take the "full afterburner" position.

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Switch symbol 145M is used to cut in the emergency system for controlling the nozzles. In this event relay v in the KAF-13D functions. If the RUD is beyond the "full afterburner" position (100° on the PURT-1F scale), a current is supplied to terminal 2 of the GA-164M (sym. 153M) plug through fuse IP-5 (sym. 154M), contacts 2-1 of relay symbol 28M and contacts 5-4 of relay F2. The flaps will have the diameter used for "maximum."

If the RUD is set beyond the "full afterburner" positon (fromm 100° to 112° on the PURT-1F scale) a supply is provided to the winding of relay F in the KAF-13D (sym. 97M) by way of the "afterburner" AZS (sym. 29Ye), contacts 2-3 of relay Z, transfer switch 4 of the PURT-1F (sym. 7Ye), and contacts 6-5 of relay v. Relay F1 operates and closes its contacts 2-3, supplying current from the aircraft network to the winding of relay F2 through the contacts of lock switch D of the KAF-13D box. Relay F2 operates and, through its own contacts 2-3 and the closed contacts 8-9 of relay V, furnishes supply to terminal 2 of the plug for the hydraulic-electric valve GA-164M (sym. 153M). The supply circuit to terminal 3 of the GA-164M plug is broken by contacts 5-4 in relay F2. The flaps will have the diameter setting for "full afterburner".

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There is a delay in the change in diamerter of the flaps between positions of the RUD for "minimum afterburner" and "full afterburner," and, in the event of emergency control, from the "full afterburner" position to the stop (100° - 112° on the PURT-1F scale).

When lock switch A is set in the closed position (lock switches B, V, G open), and with the functioning of relay F1, the supply circuit to the

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winding of relay RV1 is closed. In 0.5 second this relay, with contacts 3-2, interrupts the supply circuit to the winding of relay RV2 and the winding of relay s. Relay s has no current and, through its normally closed contacts 1-2 supplies the winding of relay F2. Relay F2 operates and its contacts 3-2 connect a supply to terminal 2 of the GA-164M (sym. 153M) valve after a delay of 0.5 second.

When lock switch B is set in the closed position (A, V, G open) the signal for shifting the flaps will be delivered from relay s with a time delay equal to 1 second, and this will close its normally closed contacts only after the contacts of relays RV1 and RV2 drop out (eabh of which will drop its contacts after 0.5 second).

When V is set in the closed position (A, B, G open), the signal for shifting the flaps will be supplied from relay s with a time delay equal to 1.5 seconds. This relay closes its normally closed contacts only after the contacts of relays RV1, RV2 and RV3 (each of which drops its contacts in 0.5 second) have dropped out.

When G is set in the closed position (A, B, V open) the signal for shifting the flaps will be delivered from relay s with a time delay equal to 2 seconds. Relay s closes its normally closed contacts only after the contacts of relays RV1, RV2, RV3 and RV4 (each of which drops its contacts in 0.5 second) have dropped out.

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When D is set in the closed positon, and when relay F1 operates, the circuit supplying the winding of relay RV1 is broken and, in 0.5 second, through contacts 3-2, interrupts the supply circuit to the winding of

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relay RV2. Relay RV2 now has no supply and in 0.5 second, through its contacts 3-2, breaks the supply circuit to the winding of relay d. Relay d goes dead and the normally closed contacts 1-2 provide a supply path to the electromagnetic valve for pump NR-22F (sym. 11Ye) and the "afterburner" pilot light (sym. 30Ye) with a delay of 1 second.

When lock switch Ye is set in the closed position the signal for cutting in the electromagnetic valve of the NR-22F and the supply to the "afterburner" pilot light will be delivered with a time delay equal to 2 seconds from relay d which closes its normally closed contacts only after the contacts of relays RV1, RV2, RV3 and RV4 (each of which drops its contacts in 0.5 second) have dropped out.

There are various combinations of settings for lock switches A, B, V and G (flap time delay) and for D and Ye (fuel time delay) so that different time delay variations for both flaps and fuel can be obtained.

The engine control lever is moved away from the "minimum afterburner" stop to cut out the afterburner regime. This results in cutting out relay F1 and opening contacts 2-3 of this relay.

The pilot light which signals that the afterburner is cut in is extinguished, the supply to relay F2 is cut off and the electromagnetic valve for the NR-22F pump (sym. 11Ye) for the afterburner is disconnected.

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4. Instruments for controlling engine operation

Instruments included in the group controlling engine operation include:

the remote electrical tachometer, ITE-2;

exhaust gas thermometer, TVG-11T;

the remote electrical oil guage, DIM-8T.

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The ITE-2 consists of:

the indicator (sym. 30K);

the low pressure rotor transmitter, DTE-1 (sym. 31K);

the high pressure rotor transmitter, DTE-1 (sym. 32K).

The indicator (sym. 30K) and the transmitters (symbols 31K and 32K) are electrically connected only to each other and are not connected to the aircraft's electrical network.

The TVG-11T consists of:

the temperature indicators (sym. 27K);

the receiver of exhaust gas temperatures (sym. 29K);

the thermocouple connecting block (sym. 28K).

The TVG-11T elements are connected electrically only with each other and have no connection with the electrical system in the aircraft.

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The DIM-8T consists of:

the indicator, UI1-8 (sym. 16Ye);

the oil guage transmitter, IDT-8 (sym. 24Ye);

the 115 volt/36 volt transformer (sym. 23Ye).

The elements of the DIM-8T are electrically interconnected. In addition, the primary winding of the transformer (23Ye) is supplied with 115 volts, 400 cycles, from converter PO-750A (sym. 1R) through fuse SP-5 (sym. 22Ye) and contacts 14-13 of the relay (symbol 32R).

Information with respect to the purposes for which the instruments are intended, as well as the scale graduations on the indicators, is given in the chapter on "Instrumentation" of this description.

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5. By-pass air door control system

General information

Two symmetrically located doors, on the port and starboard sides of the fuselage, between frames 2 and 2A, are installed in order to prevent compressor stalling action in the inlet ducts.

The doors, or flaps, open outward into the airstream. The doors are controlled both automatically and manually.

The electrical devices which do the work of controlling the doors are listed in the table.

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No.	No. of position in the electrical schematic	Name of item	Type	Quantity	Location
1	2	3	4	5	6
1	33M	Circuit breaker, "Gas sector interlock"	AZS-10	1	After electrical switchboard, starboard console, cockpit
2	120M	Transfer switch, "By-pass doors"	PPN-45	1	Port console, cockpit
3	141M	Relay	TKYe-21PD	1	Relay box, frame 11 in cockpit
4	114M	Microswitch	KV-9A	1	Fixed part of connector, frames 11-12
5	126M	Relay	TKYe-52PD	1	Relay box, cockpit frame 11
6	50M	Filter in the "M" number controller circuit	MR-1.5	1	Cockpit, behind the instrument panel
7	121M	Hydraulic-electric valve	GA-184	1	Nose-wheel housing, between frames 5 and 6, port

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The door mechanism is interlocked with the engine control lever and with the aircraft control stick.

Electrical circuit operation

For automatic control of the by-pass air doors the transfer switch (sym. 120M) is set in the "automatic" position".

When flight speed corresponds to about Mach 1.5, the supply from the aircraft network is distributed from terminal B of the filter (sym. 50M) for Mach number controller through the AZS (sym. 38M) to the relay winding (sym. 126M). The relay functions, closing contacts 2-3.

Positive voltage from the aircraft network is fed to the electrical-hydraulic valve GA-184 (sym. 121M) through AZS (sym. 33M), the contacts of the transfer switch (sym. 120M),

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contacts 2-3 of the relay (sym. 126M) and contacts 2-1 of the relay (sym. 141M). The doors open.

In order to provide for stable operation of the aircraft after acceleration to the speed corresponding to a Mach number of about 1.5, and when the afterburner is cut in, the relay operates (sym. 141M), contacts 1-2 of the relay (sym. 141M) open and the supply fed to terminal 2 of the electrical-hydraulic valve (sym. 121M) plug is interrupted. The doors close. In the event the afterburner is cut out at these speeds the relay (sym. 141M) releases and supply is fed to the electrical-hydraulic valve (sym. 141M). The doors open.

The doors open when the aircraft is in manual control and the aircraft noses up at an angle of inclination corresponding to a 20° stabilizer angle

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(large arm) of 10° (small arm) and for an aircraft speed corresponding to Mach 1.5.

In this case the supply is provided to the electrical-hydraulic valve (sym. 121M) from the aircraft network through the AZS (sym. 33M), the contacts of the transfer switch (sym. 120M), the closed contacts 2-3 of the relay (sym. 126M) and the closed contacts 3-4 of the microswitch (sym. 114M).

In the event the doors are controlled manually the transfer switch (sym. 120M) is set in one of the necessary positions: "open" or "closed".

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When the position of the transfer switch (sym. 120M) is "open" a supply is furnished to the electrical-hydraulic valve (sym. 121M). The doors open. In the "closed" position the supply to the electrical-hydraulic valve (sym. 121M) is broken. The doors close.

The doors can be opened or closed manually without regard for aircraft speed corresponding to Mach 1.5.

6. Cone control system and signals

General information

The system is designed to control the cones, a change in the position of which ensures stable operation of the power plant at super-sonic speeds.

Operation of the cone control system and signals is accomplished by the devices listed in the table.

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No.	No. of position in the electrical schematic	Name of item	Type	Quantity	Location
1	2	3	4	5	6
1	66M	M number controller	MR-1.5	1	Behind instrument panel, port, frame 6
2	50M	Filter	MR-1.5	1	Same
3	124M	M number controller	MR-1.9	1	same
		Page 137			
4	125M	Filter	MR-1.9	1	Same
5	72M	Electrical-hydraulic valve	GA-185	1	Nose-wheel housing, between frames 5-6, starboard
6	128M	Electrical-hydraulic valve	GA-183	1	Same
7	105M	Microswitch	KV-9A	1	Nose section of fuselage, frame 2
8	126M	Relay	TKYe-53PD	1	Relay box at frame 11 in cockpit
9	127M	Relay	TKYe-53PD	1	Same

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No.	No. of position in the electrical schematic	Name of item	Type	Quantity	Location
1	2	3	4	5	6
10	33M	Circuit breaker, "Gas sector interlock"	AZS-10	1	After electrical switchboard, starboard console
11	54M	Transfer switch, "Automatic," "Manual"	2PP-45	1	Horizontal section port console
12	57M	Transfer switch, "Rig Out 1.9; 1.5," "Rig In"	VTZ-602020-SP	1	Horizontal section port console
13	104M	Pilot light to signal "Cone rigged out"	Green	1	Display T-4, instrument panel
14	86M	Relay	TKYe-56PD	1	Relay box behind instrument panel, starboard, frame 6

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The aircraft air intake has a three-position cone.

Rigging in or rigging out the cone in flight is carried out automatically (depending upon the increase in the velocity head) or manually, by setting the transfer switch to the corresponding position.

When the switch is set for automatic control, and when the aircraft speed is equal to that worked out by a special controller for the first position of advance of the cone, electrical-hydraulic valve GA-185 operates. The cone advances to the first position.

When the aircraft attains a speed equal to that worked out by the special controller for the second position of advance for the cone, a second electrical-hydraulic valve, GA-185, functions.

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In this case both electrical-hydraulic valves have current supplied to them. The cone moves out to the second position - to full speed.

With a reduction in the velocity head the controller for moving the cone outward to the second position is cut out. The cone moves inward to the speed value for the second position.

With a further speed decrease the controller for moving the cone outward to the first position is cut out. The cone is completely rigged in.

Electrical system operation

When the SZS (sym. 38M) is cut in and the transfer switch (sym. 54M) is set to the "automatic" position the voltage from the aircraft network is fed to contact 5 of the relay (sym. 126M) and contacts 5 and 2 of relay symbol 127M.

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When the controller (sym. 66M) contacts close the supply is fed to the winding of the relay (sym. 126M) through terminal B of the filter (sym. 50M) from the AZS (sym: 33M). When the relay operates it closes contacts 5-6 and a voltage from the aircraft network is supplied to terminal 3 of the plug for the electrical-hydraulic valve (sym. 72M). The circuit supplying terminal 2 is opened. The supply through closed contacts 5-4 of the relay (sym. 127M) is delivered to terminal 2 of the plug

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for the electrical-hydraulic valve (sym. 128M). The circuit supplying terminal 3 is broken. The cone moves out to the first position.

When the controller contacts close (sym. 124M) a supply is furnished the winding of the relay (sym. 127M) through terminal B of the filter (sym. 125M) from the AZS (sym. 38M). The relay functions, closing contacts 5-6 and 2-3 and the voltage from the aircraft network is fed to terminal 3 of the plugs for the electrical-hydraulic valves (symbols 72M, 128M). The circuit supplying terminal 2 is broken. The cone moves out to the second position.

When the controller contacts are opened (sym. 124M) the current is removed from the relay (sym. 127M) winding. In this case contacts 5-6 break the circuit supplying terminal 3, while contacts 5-4 close the circuit supplying terminal 2 of the plug for electrical-hydraulic valve symbol 128M. The supply to the electrical-hydraulic valve symbol 72M remains unchanged.

The cone moves back to the first position.

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When the controller (sym. 126M) contacts are opened current is removed from the winding of the relay (sym. 126M). In this case contacts 6-5 break the circuit supplying terminal 2 of the plug for electrical-hydraulic valve symbol 72M. The cone returns to the initial position.

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Manual control of the outward movement of the cone is accomplished by setting the transfer switch (sym. 54M) in the "manual" position and transfer switch symbol 57M in one of three positions: "Rig Out 1.5," "Rig Out 1.9," "Rig IN".

The supply to the terminals of the plugs for the electrical-hydraulic valves (symbols 72M, 128M) is, in this case from the AZS (sym. 33M) and the closed contacts of the transfer switches (symbols 54M, 57M).

The alternate sources of supply to the terminals of the electrical-hydraulic valve plugs (sym. 72M, 128M) are the same as those for automatically rigging out or rigging in the cone in the following cases:

closing of the controller (sym. 66M) contacts - 1st cone position (rigging out);

closing of the controller (sym. 124M) contacts - 2nd cone position (rigging out);

opening of the controller (sym. 124M) contacts - 1st cone position (rigging in);

opening of the controller (sym. 66M) contacts - initial cone position (rigging in).

When the cone is rigged out to the first position the terminal switch (sym. 105M) operates and closes its contacts, feeding a voltage from the aircraft network to the pilot light (sym. 104M) through the AZS (sym. 33M) and the relay contacts 16-17 (sym. 86). The pilot light "cone rigged out" lights.

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When the cone is returned to its initial position the contacts of the terminal switch open and the pilot light (sym. 104M) goes out.

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7. Engine flight speed control lever interlock system

General information

Operation of the engine control lever (RUD) is provided for by the devices indicated in the table.

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No.	No. of position in the electrical schematic	Name of item	Type	Quantity	Location
1	2	3	4	5	6
1	75M	Electromagnet	EMO-2/2 –	1	Engine control lever, port side, between frames 7B-8
2	105M	Microswitch	KV-9A	1	Nose section of fuselage, Frame 2
3	33M	Circuit breaker for interlocking gas sector	AZS-10	1	Rear of electrical switchboard, starboard console
4	116M	Relay	TKYe-52PD	1	Relay box, frame 11, cockpit

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The operation of this system takes place in parallel with the operation of the cone control system and the compressor anti-stalling flaps and is designed to prevent engine surge

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which can occur during high flight speeds at small engine revolutions.

The engine control lever interlock system is a stop device which is moved forward with the aid of an electromagnet at speeds corresponding to $M \geq 1.5$ and prevents the shifting of the RUD towards the "low gas" stop under flight conditions such as these.

When the speed drops (at $M < 1.5$) the stop along the sector is selected automatically, thanks to which the above indicated limitation of travel of the RUD is removed.

In case of emergency the stop is selected by pushing the botton on the sector, which is mechanically connected with the stop.

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Electrical system operation

When flight speed corresponds to $M \geq 1.5$, and MR-1,5 controller (sym. 66M) causes the relay (sym. 116M) to operate. Through contacts 5-8 this relay feeds terminal 2 of the plug for the electromagnet (sym. 75M) from the AZS (sym. 38M). Contacts 5-4 break the circruit supplying terminal 1 of this same plug.

The electromagnet functions and moves the stop forward.

When speed is reduced ($M < 1.5$) no current flows in relay symbol 116M and the supply circuit to terminal 1 is broken.

The electromagnet pulls the stop inward.

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8. Engine fuel supply system and signals

General information

The system is designed to supply fuel to the engine and to signal fuel depletion.

The devices indicated in the table are involved in the operation of the system.

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No.	No. of position in electrical schematic	Name of Item	Type	Quantity	Location
1	2	3	4	5	6
1	14M	Circuit breaker, "Pump 1"	AZS-5	1	Switchboard, port console, cockpit
2	5M	Circuit breaker, "Pump 2"	AZS-5	1	same
3	9M	Circuit breaker, "Pump 3"	AZS-5	1	same
4	4K	Pilot light, "Pump 3"	SLTs-5T Green	1	Instrument panel, starboard section
5	6K	Pilot light, "Pump 1"	SLTs-51 Green	1	Same
6	18E	Relay	TKYe-21PD	1	Relay box, frames 11-12, port side
		Page 146			
7	6M	Contactor	KM-50D	1	Contactor block, star board side, frames 12-13
8	12M	Contactor	KM-50D	1	Same
9	17M	Contactor	KM-50D	1	Same
10	3K	Pressure signal	SD-3	1	Fuselage, lower, frames 21-22
11	5K	Pressure signal	SD-3	1	Port side fuselage, frame 16A
12	10M	Filter	F-37VT	1	Port side fuselage, frames 16-16A
13	7M	Filter	F-37VT	1	Same
14	15M	Filter	F-37VT	1	Lower section fuselage, port, frames 12-13
15	16M	Pump for tank group 1	422A	1	Fuselage, underneath, between frames 11-1
16	8M	Pump for tank group 2	495A-2	1	Lower section fuselag between frames 18-19
		Page 147			
17	11M	Pump for tank group 3	422A	1	Fuselage, port side, frames 21-22
18	13K	Circuit breaker "tank pressure signal"	AZS-5	1	Switchboard, port console, cockpit

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1	2	3	4	5	6
19	16K	Pilot light "depletion suspended tank"	SLTs-51 Green	1	middle section of instrument panel
20	15K	Pressure signal	SDU2-0.35	1	Port, lower section fuselage, frames 20-21
21	1K	Pressure signal	SD-3	1	Port side fuselage, frame 16A
22	2K	Pilot light "Tank in use"	Red	1	Display T-6, instrument panel
23	14K	Float transmitter	SE-1637	1	Upper fuselage, port side, frames 16-17
24	18K	Pilot light "500 liters remaining"	Red	1	Display T-6, instrument panel
25	19K	Indicating instrument, consumption gage	RTS16A-4	1	Instrument panel
26	20K	Thyratron cutout (or interrupter)	PT-56M	1	Starboard side fuselage, frames 12-13
27	21K	Consumption gage transmitter	RTS16A-4	1	Port, lower section fuselage, between frames 20-22

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Fuel is stowed in the aircraft in seven fuselage kerosene tanks, as well as in one suspended tank and in the wing tanks - sections.

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Electrical system operation

The pump (sym. 16M) for the 1st group of fuel tanks is energized from the aircraft network through terminal 2 of the pump plug and a fuse (sym. 24E) in the power unit through the closed contactor (sym. 12M).and a filter (sym. 15M). The contactor (sym 12M) operates and closes its contacts when a supply is furnished to its winding from the aircraft network through the AZS (sym. 14M) and when the aircraft network is connected to the airdrome supply or to the generator (in this case the supply is furnished to the relay (sym. 18E) winding, the relay operates and closes contacts 3-2).

The pump (sym. 8M) for the 2nd group of fuel tanks is energized by the delivery of a supply from the aircraft network to terminal 2 of the pump plug through a fuse (sym. 20E), the contactor (sym. 6M) and the filter (sym. 7M).

The contactor contacts close when the AZS (sym. 5M) is closed and voltage from the aircraft network is supplied to the contactor winding.

The pump (sym. 11M) for the 3rd group of fuel tanks is energized by the delivery of a supply from the aircraft network to terminal 1 of the pump plug through a fuse (sym. 18M), the closed contacts of the contactor (sym. 17M) and the filter (sym. 10M).

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The contactor contacts close when the AZS (sym. 9M) is closed and voltage from the aircraft network is supplied to the contactor (sym. 17M) winding.

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When the fuel is exhausted (when there is a drop in pressure in the fuel line) from the tanks in the 1st group the transmitter contacts in the pressure signal transmitter SD-3 (sym. 5K) close and "negative" is supplied to the pilot light (sym. 6K). The pilot light lights.

When the fuel in the 3rd group of tanks is exhausted the SD-3, (sym. 3K) transmitter contacts close and the pilot light (sym. 4K) lights.

When the fuel in the tank suspended from the fuselage is gone the pilot light (sym. 16K) lights because the SDU2-0.35 contacts (sym. 15K) close and "positive" is supplied to the pilot light from the aircraft network from the AZS (sym. 13K).

When the pressure in the line between the engine and the service tank drops below 0.3 kg/cm^2 the SD-2 (sym. 1K) contacts close and "positive" from the aircraft network is supplied to the signal pilot light (sym. 2K) through the AZS (sym. 13K) and contacts 16-17 of the relay (sym. 15Ye). The pilot light lights.

When 500 liters of fuel remain the contacts in the float transmitter (sym. 14K) close and feed "negative" to the pilot light (sym. 18K). "positive" is supplied to the pilot light from the AZS (sym. 13K). The pilot light lights.

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A cumulative fuel consumption meter, RTS 16A-4, is installed in the aircraft to measure the amount of fuel consumed by the engine.

The indicating instrument of the consumption meter permits visual observation of the amount of fuel remaining in the aircraft tanks with properly operating fuel lines.

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The consumption meter complex consists of a transmitter (sym. 21K), the indicating instrument (sym. 19K) and the thyratron cutout PT-56M (sym. 20 K).

The indicating instrument (sym. 19K) and the transmitter in the consumption meter (sym. 21K) are electrically connected with the thyratron cutout (sym. 20K).

The thyratron cutout (sym. 20K) PT-56M supplies 115 volts, 400 cycle alternating current from the converter PO-750A (sym. 1R) through contacts 13-14 of the relay (sym. 32R) and fuse SP-5 (sym. 30R). In emergency operation the supply is from the PO-750A (sym. 2R) converter.

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9. Engine cut-off valve control system

General Information

The system is designed to shut off the engine main fuel line.

The elements in the system are:

No.	Symbol	Name of item	Type	Quantity	Location
1	53M	Button "Engine shut-off valve"	204KS	1	Switchboard, port console, cockpit
2	52M	Electrical-pneumatic valve	(blur)5000/1A	1	Nose section fuselag port, underneath, frames 20-21
3	9K	Circuit breaker "Fire equipment, deicer"	AZS-5	1	Switchboard, port console, cockpit

In order to shut off the main fuel line supplying the engine (when dismounting aggregates and in cases of emergency) before fuel enters the engine, (there is a shut-off with an electrical-pneumatic valve) (sym. 52M).

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Electrical system operation

The electrical-pneumatic valve is cut in by pushing the button (sym. 53M). In this case a supply to terminal 1 of the valve plug flows from the aircraft netowrk through the AZS (sym. 9K) and the closed contacts in the push button (sym. 53M).

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10. Fire protection system equipment

General information

The system is designed to warn of fire in the engine compartment and to put the fire extinguisher tank in operation.

The electrical devices given in the table ensure operation of the fire protection system equipment.

No.	Symbol	Name of item	Type	Quantity	Location
1	26K	Transmitter	IS-2MS	1	Tail section fuselage, frame 29
2	24K	Electronic amplifier	IS-2MS	1	Lower section fuselage, port, frames 12-13
3	9K	Circuit breaker "Fire equipment, deicer"	AZS-5	1	Switchboard, port console, cockpit
4	25K	Pilot light "fire"	Red	1	Display T-6, instrument panel, starboard
5	22K	Push button "fire extinguisher"	205K	1	Horizontal section port console, on instrument panel
6	23K	Fire extinguisher tank	200-2-1S	1	Lower section fuselage, frame 21

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Electrical system operation

The IO-2Ms ionization fire signal device is to signal the appearance and disappearance of flame in the aircraft engine compartment.

The signal device's transmitter is a heat-resistant metal tube. The transmitters are installed on special ceramic insulators.

The operating principle of the IS-2MS is based on the property of conductivity of flame resulting from ionization which accompanies a flaming chemical reaction.

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The IS-2MS signal device functions only when flame appears in the space between the transmitter and the aircraft mass. The IS-2MS signal device will/not react to a rise in temperature. The IS-2MS signal device is an electronic device and operates practically instantaneously.

The primary winding of the transformer in the IS-2MS electronic amplifier (sym. 24K) is connected to pins 2 and 5 of the plug connector ShR20P5NSh10 and is supplied with a 115 volt, 400 cycle alternating current from the PO-750A converter (sym. 1R) through contacts 13-14 of the relay (sym. 32R) and fuse SP-5 (sym. 55R).

The grid leads of the IS-2MS device's twin triode are connected to the aircraft hull.

"Positive" rectified, stabilized voltage is fed to the leads to the transmitters via terminals 1 and 2 of plug ShR20P2NG6. /TN: The plural "transmitters" is translated exactly./

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In the event flame appears in the space between the transmitter and the mass of the aircraft the air space becomes electrically condutive.

This is equivalent to connecting a resistance on the order of 5 to 6 megohms between the grid and the plate of the tube. A positive potential is supplied to the grid. The plate current rises and reaches a value such that the relay functions. When the relay functions a supply is furnished to the "fire" pilot light (sym. 25K) from the aircraft network through the AZS (sym. 9K), the closed contacts of the amplifier relay (sym. 24K), and contacts 1-2 of the relay (sym. 15K).

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The button (sym. 22K) must be pushed in order to put the fire extinguisher tank into operation. In this case the supply is from the aircraft network to the tank (sym. 23K) via the AZS (sym. 9K) and the closed contacts of the push button.(sym 22k).

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11. System for measuring pressure in the main and booster hydraulic systems and signals

General information

A remote electrical pressure gage, 2EDM-250, serves to measure the pressure of the hydraulic fluid in the hydraulic system.

Included in the 2EDM-250 electrical pressure gage complex is:

the DV-250 electrical pressure transmitter (sym. 12K) in the main hydraulic system;

the DV-250 electrical pressure transmitter (sym. 17K) in the booster hydraulic system;

the remote electrical indicator 2EDMU-250 (sym. 11K).

The DV-250 transmitters (sym. 12K, 17K) are installed between frames 21-22 starboard, below, and at frame 20, port, respectively.

The 2EDMU-250 electrical indicator (sym. 11K) is located beneath the starboard movable section of the instrument panel.

The transmitter and indicator are electrically interconnected. In addition, the indicator (sym. 11K) is supplied with a voltage from the aircraft network through the AZS (sym. 13K) "EDM, gidr. ost. gor. sign. podn. rash. bakov" (T.N.: "EDM" is the remote electrical pressure gage; "gidr" is hydraulic; "sign." is signal; "bakov" is "of tanks"; the others are uncertain and can not be fully reconciled with that function of 13K shown in the table on text page 147.)

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The way in which lack of pressure in the booster and in the main hydraulic systems is signalled results from the operation of the devices indicated in the table.

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No.	Symbol	Name of item	Type	Quantity	Location
1	83M	Circuit breaker "booster system cutout, hydraulic signal"	AZS-5	1	Cockpit, starboard rear switchboard
2	43K	"Booster" pilot light	SLTs-51 Yellow	1	Instrument panel, starboard section
3	44K	"Main" pilot light	SLTs-51 Yellow	1	Same
4	85M	Relay	TKYe-56PD	1	Relay box behind instrument panel, starboard, frame 6
5	45K	Relay	TKYe-21PD	1	Relay box, frame 11, in cockpit
6	46K	Pressure relay	GA-135T	1	Fairing, between frames 31-31A

Electrical system operation

When the pressure in the main hydraulic system drops to 165 kg/cm^2 relay GA-135T (sym. 46K) operates and supplies "negative" to the pilot light (sym. 44K), while "positive" is supplied from bus number 3 of the rear electrical switchboard of the starboard console through the AZS (sym. 83M). The lamp lights.

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When the pressure in the booster hydraulic system also falls to 165 kg/cm2 the pilot light will burn (sym. 43K) because "negative" is supplied to it through contacts 1-2 of the relay and the nagative circuit of the relay (sym. 45K) TKYe-21PD winding is broken by the contacts in the GA-135T hydraulic relay (sym. 60M).

When the switch (sym. 89M) is cut in and the pressure in the booster hydraulic system drops, the contactor winding (sym. 70M) circuit is closed and the contactor functions and supplies current from the bus of the power unit to terminal 2 of the pump station plug. Pump station NP-27 (sym. 79M) begins to operate.

When the pressure in the main hydraulic system rises to 195 kg/cm2 the negative circuit to the pilot light (sym. 44K) is broken by contacts O-NZ of the hydraulic relay (sym. 46K). The pilot light (sym. 44K) goes out.

When the pressure in the booster hydraulic system rises to 195 kg/cm2 the negative circuit to the contactor (sym. 70M) winding is broken by contacts O-NZ in the hydraulic relay (sym. 60M). The contactor carries no current and the supply to pump station NP-27T (sym. 79M) is opened. At the same time the hydraulic relay (sym. 60M) furnishes "negative" to the winding of relay symbol 45K through contacts O-NR.

The relay (sym 45K) operates and opens the negative circuit to the pilot light (sym. 43K). The pilot light (sym. 43K) goes out.

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12. Pump station control system

General information

Operation of the system for controlling the cutting in and cutting out of the pump station is provided for by the devices shown in the table.

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No.	Symbol	Name of item	Type	Quantity	Location
1	2	3	4	5	6
1	79M	Pump station	NP-27T	1	Forward fairing of fin, frames 32A-33
2	70M	Contactor	KM-100D	1	Contactor block, starboard side fuselage, frames 12-13
3	60M	Pressure relay in hydraulic system	GA-135T	1	Back fairing frames 30-31
4	89M	Switch, "Pump Station"	87K	1	Forward switchboard, starboard console
5	71M	Fuse	IP-75M	1	Starboard side fuselage, frames 11-12
6	110M	Fuse	IP-5	1	Same

Pump station NP-27T is installed in the booster hydraulic system to ensure landing with a locked (zaklinennyy) engine. It is cut into the system automatically when the pressure in the booster system drops to 165 kg/cm^2 and cuts out when the pressure builds up to 195 kg/cm^2.

Electrical system operation

Pump station NP-27T (sym. 79M) is cut in when a supply is provided from the aircraft network to terminal Z of the plug for the NP-27T via the fuse (sym. 71M) and closed contactor contacts (sym. 70M). The contactor contacts (sym. 70M) close when the switch (sym. 69M) is cut in and the pressure in the hydraulic system drops to 165 kg/cm^2. In this case contacts ("O"-"NZ") in the relay (sym. 60M) close and supply current from the aircraft network to the contractor (sym. 70M) winding through the fuse (sym. 110M), the transfer switch (sym. 69M) contacts and the relay (sym. 60M) contacts.

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When the pressure increases to 195 kg/cm^2 contacts "O"-"NZ" in the relay (sym. 60M) open and the supply circuit to station NP-27T is broken. The pump cuts out.

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13. Stabilizer and aileron booster control system

General information

The devices which ensure system operation are given in the table.

No.	Symbol	Item	Type	Quantity	Location
1	83M	Circuit breaker, "booster system cutout, hydraulic system signal"	AZS-5	1	After electrical switchboard, starboard console, cockpit
2	90M	Push button	204K	1	Horizontal section, starboard console
3	85M	Relay	TKYe-52PD	1	Relay box, frames 31A-32, dorsal section of fin
4	81M	Electrical-hydraulic valve	GA-1905	1	Back fairing, fuselage, between frames 32-32A
5	112M	Fuse	IP-10	1	Power unit, starboard side, frames 11-12
6	113M	Fuse	IP-10	1	same
7	26M	Transfer switch	88K	1	Horizontal section port console, cockpit

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8	84M	Relay	TKYe-52PD	1	Relay box, between frames 15-16, port side
9	27M	Electrical-hydraulic valve	GA-1905	1	Lower section fuselage, between frames 20-22
10	82M	Electrical-hydraulic valve	GA-1905	1	same

Longitudinal and transverse control of the aircraft is carried out from the control stick through non-reversible boosters supplied from the aircraft's hydraulic system. The stabilizer is controlled with the aid

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of a two-chamber booster, BU-51M and an ARU-3V automatic device. The ailerons are controlled by two BU-45 boosters.

Electrical system operation

The stabilizer booster, BU-51M, is cut in with the aid of the electrical-hydraulic valve (sym. 81M). When voltage from the aircraft network is present there is a supply to terminal 3 of the valve (sym. 81M) plug via the fuse (sym. 112M) and the relay (sym. 85M) contacts 1-2.

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The aileron boosters, BU-45, are cut in when the transfer switch (sym. 26M) is set to the "on" position.

In this case the aircraft voltage issupplied to terminal 3 of the electrical-hydraulic valve (sym. 27M) for cutting in the BU-45 booster which operates off the main hydraulic system, the supply coming through the fuse (sym. 113M) and the switch (sym. 26M) contacts.

The aircraft voltage is, simultaneously, fed to terminal 3 of the electrical-hydraulic valve (sym. 82M) for cutting in the BU-45 booster which operates off the booster hydraulic system, the supply coming through relay (sym. 84M) contacts 1-2.

When the push button (sym. 90M), which cuts in the AZS (sym. 83M), is pressed the stabilizer and aileron boosters, which operate off the booster hydraulic system, are cut off.

At the same time, supply is provided for the windings of the relays (sym. 85M, 84M). The relays function. Contacts 1-2 break the supply circuit to terminal 3 of the plugs for the electrical-hydraulic valves (sym. 82M, 81M) and contacts 6-5 close the circuits supplying terminal 2.

The BU-45 aileron boosters are cut out by setting transfer switch (sym. 26M) "off". This opens the supply circuit to terminal 3 of the plug for electrical-hydraulic valves (sym. 27M, 82M) and opens the supply circuit to terminal 2.

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14. Stabilizer control system

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General Information

Operation of the stabilizer control system is carried out by the devices given in the table.

No.	Symbol	Name of Item	Type	Quantity	Location
1	2	3	4	5	6
1	62M	Control block	ARU-33-2N series	1	Cockpit, starboard side, frames 10-11
2	73M	Execution mechanism	ARU-3V	1	Back fairing, fuselage frames 29-30
3	74M	Position indicator	ARU-2	1	Instrument panel
4	58M	Electrical mechanism	MP-100M	1	Back fairing, fuselage frames 30-31
5	87M	Circuit breaker, "ARU automatic control"	AZS-5	1	Starboard console, cockpit, after electrical switchboard
6	68M	Circuit breaker, "ARU manual control"	AZS-5	1	Starboard, after electrical switchboard in cockpit
7	67M	Transfer switch, "Manual-Automatic"	2SP-46	1	Port console, cokkpit
8	64M	Transfer switch, high speed--low speed"	PN-154	1	Port console, cockpit

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9	55M	Switch	87K	1	Forward switchboard, starboard console, cockpit
10	56M	Switch	PK-4	1	Control stick
11	85M	Relay	TKYe-52PD	1	Relay box, tail section fuselage, frames 31A-32

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1	2	3	4	5	6
12	86M	Relay	TKYe-56PD	1	Relay box behind instrument panel, frame 6
13	81M	Electrical-hydraulic valve	GA-1905	1	Back fairing fuselage, between frames 32 A
14	69M	Pilot light for signalling neutral position of trim effect	SM-30 (green)	1	Display T-4, instrument panel
15	78M	Pilot light for signalling the large arm of the ARU-3V-2 series	SM-30 (green)	1	same

Longitudinal control of the aircraft is obtained with the aid of the control stabilizer, through booster BU-51M, which controls both positions of the stabilizer simultaneously.

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The stabilizer control system includes the ARU-3V automatic device, which automatically changes the transmission ratio from the control stick to the stabilizer and, at the same time, to the spring loaded mechanism.

The adjustment law carried out by the ARU-3V is a function of the velocity head and the altitude and is determined by the aircraft aerodynamics.

A spring loaded mechanism is installed in the stabilizer control system to duplicate the aerodynamic forces on the control stick. The mechanism duplicates the forces on the control stick in proportion to its deflection and to the position of the arm in the ARU-3V aggregate.

The ARU-3V automatic device consists of the acuating mechanism, the control block, and the position indicator.

At low instrument flight speeds at elevations of more than 10,000 meters the position of the coupling rod is not dependent upon the instrument speed. The load on the control stick is minimum, while the stabilizer deflection is maximum.

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At high instrument speeds and at elevations of from 0 to 5,000 meters the load on the stick is maximum, while the stabilizer deflection is minimum.

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At intermediate altitudes of from 5,000 to 10,000 meters, the automatic device functions in accordance with the velocity head, as well as with the altitude.

In the event an instrument speed less than the speed at the end of the adjustment is achieved at an intermediate altitude, the actuating coupling rod stops, despite any further increase in the speed.

The manner in which the automatic device carries out the adjustment law is not a smooth one but, rather, takes place intermittently, in short pulses and is signalled by the ARU position indicator, while, in the extreme initial position this is done by a green pilot light installed on the instrument panel.

A switch, installed on the cockpit's port console, is used to control the ARU-3V automatic device. When the switch is thrown to the "automatic" position the actuating mechanism functions automatically from the control block. When the switch is set in the "manual" position the actuating mechanism is reset from the large arm to the small arm, and vice versa when the manual pressure switch is used.

The spring loaded mechanism serves to feed the aerodynamic forces to the stick in proportion to the angle of inclination, speed and flight altitude.

The more the stick is displaced, the greater the spring compression and force loading the stick.

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The MP-100M trimmer effect mechanism performs the aerodynamic function

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of a trimmer, shifting at the desire of the pilot, the neutral position of the loading mechanism, which permits the in-flight longitudinal a balancing of the aircraft with respect to forces.

The rotational movement of the electric motor in the MP-100M is converted into forward motion of a screw. The screw is retracted or run out, depending upon the direction of movement of the electric motor rotor and moves the body of the loading mechanism which is connected with it. When the body of the loading mechanism is displaced by the amount of compression of the springs in the loading mechanism the load acting on the stick is completely removed.

When the screw is in the limit positions microswitches function. These switches are installed in the electrical mechanism and cut out the e electric motor in one of the positions.

The mechanism is controlled by pushing the transfer switch on the aircraft stick. When the transfer switch is pushed to the "dive" position, and with the booster cut in and normal pressure being delivered to the hydraulic system, the forward end of the stabilizer is tilted upward (with a free control stick).

In the neutral position the screw in the electrical mechanism MP-100M operates a microswitch which cuts in the green pilot light "trimmer neutral" on the instrument panel.

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Electrical system operation

The BU-51M stabilizer booster is cut in when voltage is present in the aircraft network and when it is supplied to terminal 3 of the electrical-

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hydraulic valve (sym. 81M) plug through a fuse (sym. 112M) and the closed contacts 1-2 of a relay (sym. 85M).

The spring loaded mechanism duplicates the forces acting on the control stick. Longitudinally acting forces resulting from pitching or diving of the aircraft are removed from the stick by the MP-100M (sym. 58M) electrical mechanism. Voltage is supplied to terminal B or terminal A of the MP-100M (sym. 58M) plug through a fuse (sym. 111M), the closed contacts of the switch (sym. 55M) and the correspondingly closed contacts of the button switch (sym. 56M) in the "dive" or "pitch" positions.

Displacement of the neutral position of the loading mechanism occurs simultaneously with this above indicated action. The pilot light (sym. 69M) which signals the neutral position for trim effect lights up when the contacts in the terminal switch for the electrical mechanism MP-100M (sym. 58M) close at that instant which corresponds to the position of the stabilizer and the electrical mechanism MP-100M for the specified equalizing speed.

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When the AZS (sym. 87M) is cut in and the transfer switch (sym. 67M) is set to the "automatic" position aircraft network voltage is fed through terminal 4 of the control block (sym. 62M) plug to the voltage divider, the contacts of relay RS-3 and the armature "Ya" of the RPS relay.

The RPS relay operates either according to the altitude (Ya closes with contact P) or according to speed (Ya closes with contact L), according to the mismatch voltage from the potentiometric bridges, formed by the potentiometric altitude transmitters, the potentiometric speed transmitters and the feedback pptentiometric in the actuating mechanism

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of the ARU-3V (sym. 73M) automatic device, which flows in windings 1-2, 3-4, 5-6 of the RPS relay in the control block (sym. 62M).

Winding 11-12 is a positive feedback element and serves to stabilize the operation of the RPS relay.

When contacts Ya and P close aircraft network voltage is supplied to the winding of relay RS-3 "BP" (large arm), while, when contacts Ya and L close, the voltage is supplied to the "MP" (small arm) winding of relay RS-3.

Relay RS-3 functions and, when the contacts are closed, supplies a voltage from the aircraft network to the reverser winding of the MP-100M electric motor through the AZS (sym. 87M).

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The microswitches for the run out and retracted positions of the coupling rod in the actuating mechanism (sym. 73M) are the terminal switches for the extreme positions of the mechanism.

Connected with the position of the coupling rod in the actuating mechanism is the position of the slide in the potentiometer for signalling stabilizer position in the actuating mechanism ARU-3V (sym. 73M).

The slide picks off the voltage, some, or all, of the aircraft network voltage(the AZS symbol 68M must be cut in) and supplies it to the indicator (sym. 74M) arms.

When the transfer switch (sym. 75M) is set in the "manual" position, and the transfer switch (sym. 64M) for "high speed - Low speed" is set to the desired position a voltage is supplied to the corresponding winding in the reverser of the MP-100M electric motor in the actuating mechanism (sym. 73M).

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Thus, it is possible to manually change the position of the coupling shaft arm in the ARU-3V (sym. 73M) actuating mechanism.

At "large arm", the pilot light (sym. 78M) positive circuit closes through the contacts of the actuating mechanism (sym. 73M) microswitch. The pilot light (sym. 78M) burns.

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15. Landing gear control system and signals

General Information

The system is designed to lower and to retract the landing gear and to indicate the position the landing gear is in.

The control and indication system operation is carried out by the devices listed in the table.

No.	Symbol	Name of item	Type	Quantity	Location
1	2	3	4	5	6
1	34M	Circuit breaker, "landing gear control, housed"	AZS-5	1	After electrical switch board, starboard console, cockpit
2	35M	Transfer switch, "landing gear retracted," "lowered"	PPN-45	1	Instrument panel, port section
3	36M	Electrical-hydraulic valve	GA-142/1	1	Lower starboard section fuselage between frames 23-24
4	43M	Microswitch	KV-9A	1	Port wing, rib 1
5	76M	Relay	TKYe-52PD	1	Relay box, cockpit, frame 11
6	118	Flight-landing indicator	PPS-2	1	Instrument panel, port section
7		Pilot lights:			
		"nose wheel retracted"	Red		

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1	2	3	4	5	6
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		"nose wheel down"	Green		
		"landing gear release"	Red		
		"starboard down"	Green		
		"starboard retracted"	Red		
		"port down"	Green		
		"port retracted"	Red		
8	10S	Pilot light "landing gear release"	SLTs-51 Red	1	Instrument panel, amidships section
9	3S	Terminal switch	VK-44	1	Port removable wing section, between ribs 4-5
10	4S	Terminal switch	VK-44	1	Port removable wing section, ribs 1-2
11	8S	Terminal switch	VK-44	1	Starboard removable wing section, between ribs 1-2
12	7S	Terminal switch	VK-44	1	Starboard removable wing section, between ribs 4-5
13	5S	Terminal switch	VK2-140R	1	Frame (Possibly 6), bottom
14	6S	Terminal switch	VK2-140R	1	Frame (Possibly 7A), bottom
15	14S	Pilot light	KhS-39	1	Port landing gear panel
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16	12S	Pilot light	KhS-39	1	Starboard landing gear panel
17	13S	Pilot light	KhS-39	1	Receptacle, nose wheel landing gear

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1	2	3	4	5	6
18	2S	Circuit breaker, "Landing gear indicator, ANO"	AZS-5	1	After electrical switchboard, starboard console, cockpit
19	15S	Relay	TKYe-53PD	1	Relay box behind instrument panel
20	41S	Circuit breaker	AZS-25	1	Forward electrical switchboard, starboard console.

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Electrical system operation

The landing gear is lowered by setting the transfer switch (sym. 35M) in the "lowered" position.

This causes a voltage from the aircraft network at terminal 2 of the electrical-hydraulic valve (sym. 36M) plug, the supply coming through the contacts of closed AZS symbol 34M and the contacts of the transfer switch (sym. 35M).

The landing gear is retracted by setting the transfer switch (sym. 35M) in the "retract" position.

This results in a voltage at terminal 3 of the electrical-hydraulic valve plug (sym. 36M), while, at the same time, the supply to terminal 2 is broken.

The landing gear indicators operate as follows:

during take-off the landing gear is down, contacts O-1 in the terminal switches (sym. 3S, 7S) are closed, as are contacts O-N3 in terminal switch symbol 5S. Pilot lights "nosewheel down," "port down," and "starboard down" on PPS-2 (sym. 11S) burn;

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in flight the landing gear is retracted and pilot lights "port down," "starboard down," and nosewheel down" do not burn; that is, contacts 0-1 in the terminal switches (sym. 3S, 7S) and contacts 0-NZ (sym. 5S) are interrupted. The pilot lights "port retracted," "starboard retracted," and "nosewheel retracted" burn; that is contacts 0-1 in the terminal switches (sym. 4S, 8S) and 0-NR (sym. 6S) are closed. The pilot lights "landing gear release" on the PBS-2, symbols 11S and 10S are out since the

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negative circuit has been broken by contacts 3-4 of the microswitch (sym. 43MO) when the flaps are returned to neutral.

NOTE. When the flaps are deflected from the neutral position the "landing gear release" lights will not burn either because the circuit which connects them to the aircraft network through the AZS (sym. 2S) and contacts 0-2 of the terminal switch (sym. 7S) will be broken by the 1-2 contacts in the relay (sym. 76M) which is in the self-feed position through contacts 5-6.

Upon landing the landing gear is down, the pilot lights "port down," "starboard down," and "nosewheel down" burn since the contacts 0-1 in terminal switches (sym. 3S and 7S) and 0-NZ in terminal switch symbol 5S are closed. The pilot lights "port retracted," "starboard retracted," and "nosewheel retracted" on the PPS-2 (sym. 11S) are extinguished.

The "landing gear release" pilot lights will not be on. These lights will burn if, during the landing, the flaps are deflected from the neutral position and the landing gear is retracted. In this event "negative" is supplied to the lights through the closed contacts 3-4 of the microswitch

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(sym. 43M), while voltage from the aircraft network comes through the AZS (sym. 2S), contacts 0-2 of the terminal switch (sym. 7S) and the normally closed contacts 1-2 of the relay (sym. 76M).

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The pilot lights (sym. 12S, 13S, 14S) for external indication of landing gear being down will burn only when the AZS (sym. 41S) is cut in and the relay (sym. 15S) has operated. Then contacts 8-9, 5-6 and 2-3 in the relay (sym. 15S) close the negative circuit to the external indication pilot lights, while contacts 0-NZ and 0-1 in the terminal switches (sym. 5S, 3S, 7S) close the aircraft network supply circuits.

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16. Automatic landing gear wheel brake release system

General information

The devices indicated in the table provide for the operation of the automatic landing gear wheel brake release system.

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No.	No. of position in electrical schematic	Name of item	Type	Quantity	Location
1	2	3	4	5	6
1	20M	Circuit breaker, "automatic wheel brake cut-out"	AZS-10	1	Electrical switchboard port console, cockpit
2	21M	Electrical-pneumatic switch	UP-22	1	Cockpit, frame 6, starboard
3	23M	Electrical-pneumatic valve	UP-53/1-2	1	Panel, starboard landing gear
4	25M	Inertial transmitter	UA-23/2-300-10	1	Starboard landing gear
5	134M	Relay	TKYe-52PD	1	Relay box, between frames 11-12, port side fuselage
6	92M	Electrical-pneumatic valve	UP-53/1-2	1	Nose section fuselage, between frames 6-7, starboard

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7	91M	Inertial transmitter	UA-24/2	1	Nosewheel landing gear
8	93M	Relay	TKYe-52PD	1	Relay box, between frames 11-12, port side fuselage
9	22M	Electrical-pneumatic valve	UP-53/ 1-2	1	Panel, port landing gear
10	24M	Inertial transmitter	UA-23/ 2-300-9	1	Port landing gear

In the event that an abrupt reduction in the angular velocity of the wheels takes place, or in the event the brakes "lock" the electromagnetic valves, under the influence of electrical pulses transmitted by the inertial transmitters, purge the air from the brake chambers and release the wheel brakes.

The electomagnetic valves and the inertial transmitters are so connected electrically that if there is an abrupt reduction in the angular velocity, or if one of the main wheels should "lock," one of the main wheels and the nose wheel are released. If the nosewheel should "lock" only the nosewheel brakes are released.

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Electrical System Operation

When the brake lever on the aircraft control stick is pressed the air enters the UP-22 (sym. 21M) from the pneumatic system. The electrical circuit contacts are closed.

When the AZS (sym. 20M) is cut in aircraft network voltage is fed to the terminals of the pneumatic valves UP-53/1-2 (sym. 22M, 23M, 92M) and to the relay windings (sym. 93M, 134M).

Should there be a sharp reduction in speed, or should a "lock" occur in one, or in both wheels of the main landing gear, the electrical-pneumatic valves function (sym. 22M, 23M) as a result of the closing of the negative circuit in one or both of the inertial transmitters (sym. 24M, 25M). The air is purged from the brake chamber, releasing one or both wheels of the main gear.

At the same time that the port wheel is released the relay (sym. 93M) functions, the result of supply of negative voltage to its winding through the closed contacts of the inertial transmitter (sym. 24M).

The circuit supplying the electrical-pneumatic valve (sym. 92M) is through the 3-2 and 5-6 contacts of the relay (sym. 93M). This relay operates and releases the nose wheel brakes.

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At the same time that the starboard wheel brakes are released the relay (sym. 134M) functions since it is supplied with a negative voltage at its winding through the closed contacts of the inertial transmitter (sym. 25M). The circuit supplying the electrical-pneumatic valve (sym. 92M) is through contacts 3-2 and 5-6 of the relay (sym. 134M). The valve functions and the nose wheel brakes are released.

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Thus, the nose wheel brakes are released when the brakes on either the port or starboard wheel are released, as well as when both wheel brakes on the main landing gear are released.

Should there be a sharp reduction in the angular velocity (or in the event a "lock" forms) of the nose wheel alone the electrical-pneumatic valve (sym. 92M) operates since the contacts in the inertial transmitter (sym. 91M) negative circuit are closed and only the nose wheel brakes are released.

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17. Speed brake control system and signals

General information

The system is designed to extend and house the speed brakes as well as to provide an indication as to their position.

The devices which carry out the operation of the system for controlling the speed brakes and providing the signal indications, are given in the table.

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No.	Symbol	Name of item	Type	Quantity	Location
1	22S	Circuit breaker, "Speed brakes"	AZS-5	1	After electrical switchboard, starboard console, cockpit
2	30M	Transfer switch	KV-9	1	Throttle knob
3	31M	Push button	204KS	1	Aircraft control stick
4	133M	Microswitch	KV-9A	1	Suspended fuel tank pylon, frames 17-18
5	122M	Electrical-hydraulic valve	GA-184	1	Lower, starboard section fuselage between frames 25-26
6	32M	Electrical-hydraulic valve	GA-140	1	Lower, starboard section fuselage between frames 20-22
7	9S	Terminal switch	VK2-140R	1	Fuselage, between frames 12-13, port, underneath

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Speed brake control is accomplished with the electrical-hydraulic valves GA-140 and GA-184, with the aid of the push button set in the aircraft control stick, or with the transfer switch set in the throttle control lever. The push button and the transfer switch are connected in parallel in the circuit. When the button is not held down, and with the transfer switch open, the brakes are housed.

When the button is depressed, or the transfer switch is closed, voltage is supplied to the electrical-hydraulic valves, the brakes are extended and deflected to the determined angle. The "speed brakes extended" light on the flight and landing indicator PPS-2 goes on.

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Extension of the lower brake is blocked by the suspended fuel tank (the lower brake is extended only when the suspended fuel tank has been jettisoned).

Electrical system operation

Closing the AZS (sym. 22S) supplies voltage from the aircraft network to the push button (sym. 31M) and to the transfer switch (sym. 30M). When the button is depressed or when the transfer switch is cut in, the supply circuit is closed to terminal 2 of the electrical-hydraulic valve (sym. 32M) plug.

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The wing brakes are extended. Should the suspended fuel tank be jettisoned, contacts 1-2 in the microswitch (sym. 133M) close and a voltage is supplied through these contacts to terminal 2 of the electrical-hydraulic valve (sym. 122M) plug. The lower brake is also extended. If the suspended fuel tank has not been jettisoned the lower brake remains housed.

When the button is released, or when the transfer switch is opened the supply circuit to terminal 2 of the valve plugs (sym. 32M, 122M) is broken and the brakes retract.

When the brakes are in the extended position terminal switch (sym. 9S) operates, losing its contacts 0-NZ. The voltage which is supplied from the aircraft network through the AZS (sym. 2S) and the closed contacts now is applied to the pilot light which indicates "speed brakes extended." The light goes on.

The light is not on when the speed brakes are housed.

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18. Flap control system and signals

The system is designed to extend and retract the flaps when taking off and landing.

The devices indicated in the table provide for system operation.

No.	Symbol	Name of item	Type	Quantity	Location
1	34M	Circuit breaker, "flaps, landing gear"	AZS-5	1	After electrical switchboard, starboard console
2	39M	Flap control mechanism	MZ	1	Horizontal section port console
3	43M	Microswitch	KV-9A	1	Port removable section of wing, after section of wing rib, No. 1
4	44M	Electrical-hydraulic valve	GA-185	1	Lower starboard section fuselage between frames 22-23

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The flap control system is electrical-hydraulic. The flaps can be housed and extended by pressing the corresponding buttons in the flap control mechanism.

Electrical system operation

When the "extend" button in the flap control mechanism (sym. 39M) is pressed the aircraft network voltage is supplied to terminal 2 of the electrical-hydraulic valve (sym. 44M) plug through the closed AZS (sym. 34M) and the closed contacts 4-3 of the terminal transfer switch in the flap

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control mechanism (sym. 39M). The circuit supplying terminal 3 of the electro-hydraulic valve plug is interrupted by contacts 1-2 of the terminal transfer switch in the mechanism (sym. 39M).

The electro-hydraulic valve functions. The flaps extend. The pilot light indicating "flaps extended" on the PPS-2 (sym. 11S) lights up since the closed contacts 3-4 of the microswitch (sym. 43M) complete the circuit.

When the "retract" push button is pressed the supply is to terminal 3 of the electro-hydraulic valve (sym. 44M) plug and comes through contacts 1-2 of the terminal transfer switch of the mechanism (sym. 39M). The circuit supplying terminal 2 is interrupted by contacts 4-3 in the terminal transfer switch.

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The electro-hydraulic valve functions, and the flaps are retracted. The pilot light indicating "flaps extended" on the PPS-2 (sym. 11S) is out because contacts 3-4 in the microswitch (sym. 43M) are open.

If, when the flaps are extended, the landing gear is not down, pilot lights indicating "lower landing gear" on the PPS-2 and the pilot light symbol 10S light up (the voltage from the aircraft network to the pilot light is supplied from the AZS (sym. 2S) through contacts 0-2 of the terminal switches (sym. 3S, 7S) and contacts 1-2 of the relay (sym. 76M). When the landing gear is released contacts 0-2 of the terminal switch (sym. 4S) close and a voltage from the aircraft network is supplied to the relay (sym. 76M) winding through the AZS (sym. 2S). The relay (sym. 76M) functions blocks itself and, with contacts 1-2, opens the circuit supplying the pilot light "lower landing gear" and the light goes out.

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19. Drag-chute control system

General information

The system is designed to release the parachute in order to shorten the aircraft's landing run.

The devices shown in the table ensure system operation.

No.	Name of item	Type	Quantity	Location
1	46M Circuit breaker "Drag-chute"	AZS-5	1	After electrical switchboard, starboard console, cockpit
2	129M Push button "release parachute"	5KS	1	Port upper section instrument panel
3	131M Push button "drop parachute"	204KS	1	Port console, cockpit
4	130M Electro-pneumatic valve	695000/A	1	Tail section fuselage, between frames 30-31, underneath, starboard
5	132M Electro-pneumatic valve	695000/A	1	Tail section fuselage, between frames 30-31, underneath, starboard

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Electrical system operation

The system controlling the drag-chute is an electrical and air one.

Release of the drag-chute is accomplished by pushing button symbol 129M, whereupon a voltage from the aircraft network is supplied via the AZS (sym. 46M) to terminal 1 of the electro-pneumatic valve (sym. 130M) plug. The valve functions and opens the air inlet in the flap control system. The flaps open.

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The parachute, of its own weight, falls out of its container and deploys.

Jettison action occurs when the push button (sym. 131M) "drop parachute" is pressed. The aircraft network voltage is supplied from the AZS (sym. 46M) to terminal 1 of the electro-pneumatic valve (sym. 132M) plug. The valve (sym. 132M) functions and air is by-passed from the air system into the coupling lock cylinder. The drag-chute is uncoupled.

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20. System for controlling landing lights, UFO, ANO, cockpit and portable lights

General information

The system is designed to illuminate the take off and landing strips during landing and taxying, to illuminate guage scales, the cabin, and certain places in the aircraft.

The devices contained in the system are indicated in the table.

No.	Symbol	Name of item	Type	Quantity	Location
1	2	3	4	5	6
1	41S	Circuit breaker, "landing lights, external landing gear signal"	AZS-25	1	Forward electrical switchboard, starboard console, cockpit
2	42S	Transfer switch "landing lights," "landing," "retract" "taxi"	VTZ602020SP	1	Port section of Instrument panel
3	44S	Landing light	MPRF-1A	1	Port removable wing section between ribs 1-2
4	43S	Landing light	MPRF-1A	1	Starboard removable wing section between ribs 1-2

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1	2	3	4	5	6
5	48S	Relay	TKD-12PD	1	Relay box between frames 11-12
6	49S	Relay	TKYe-56PD	1	same
7	2S	Circuit breaker landing gear signal, "ANO"	AZS-5	1	After electrical switchboard starboard console, cockpit
8	16S	Transfer switch, "ANO," "low," "medium," "high"	PEPN-20	1	Port console, cockpit
9	17S	Resistance	P2V-25Kh-15	2	Relay box, cockpit, frame 11
10	19S	Side light	BANO-45	1	Port side, port removable wing section, between wing rib tips nos. 18-19
11	20S	Tail light	KhS-39	1	Tip of tail fin
12	21S	Side light	BANO-45	1	Starboard removable wing section, between wing rib tips nos. 18-19
13	35S	Circuit breaker "ARU FOSh, switch for lamp for illuminating KKO, AGD"	AZS-5	1	After electrical switchboard, starboard console, cockpit
14	38S	Rheostat	RUFO-45	1	Starboard console, cockpit

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1	2	3	4	5	6
15	39S	Rheostat	RUFO-45	1	Starboard console, cockpit
16	37S	Light for ultraviolet illumination	ARUFOSh-45	1	Aircraft control stick

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1	2	3	4	5	6
17	40S	Light for ultra-violet illumination	ARUFOSh-45	1	Port side cabin, frames 7B-8
18	36S	Receptacle	47K	1	Starboard side, cockpit
19	34K	Circuit breaker "sig. gen. ZUP, KLS"	AZS-5	1	Electrical switch-board, port con-sole, cockpit
20	1S	Cockpit light	KLSRK-45	1	Starboard side cockpit
21	45S	Receptacle	47K	1	Port wing

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Electrical system operation

The landing lights (sym. 44S and 43S) are controlled with the aid of a transfer switch (sym. 42S) and two relays (sym. 48S and 49S).

When the switch (sym. 42S) is thrown to the "landing" position voltage from the aircraft network is supplied from the AZS (sym. 41S) switch to the windings of the relays (sym. 48S and 49S), and the relays operate.

Voltage from the AZS (sym. 41S) is supplied to terminal 2 of the lights (sym. 44S and 43S) through terminals 12-11 and 9-8 of the relay (sym. 49S) and the lights are extended.

Voltage is supplied to terminal 4 of the lights (sym. 44S and 43S) through the fuse IP-30 (sym. 50S), terminals 2-6 and 1-5 of the transfer switch (sym. 42S) and terminals 2-3 and 5-6 of the relay (sym. 48S). The lights go on, burning on the "high beam."

When the transfer switch (sym. 42S) is set in the "taxi" position the aircraft network voltage is fed from the AZS (sym. 41S) switch to the relay winding (sym. 49S). The relay functions and the lights are extended.

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The voltage path is from the IP-30 fuse (sym. 50S) to terminal 5 of the lights (sym.44S and 43S) through terminals 5-4 and 2-1 of the relay (sym. 48S) and terminals 18-17 and 15-14 of the relay (sym. 49S). The lights go on, burning on the "low beam."

When the transfer switch (sym. 42S) is set to the "retract" position the aircraft network voltage is supplied either from the AZS (sym. 41S) switch or from the IP-30 fuse (sym. 50S) to terminal 3 of the lights (sym. 44S and 43S) through terminals 2-4 and 1-3 of the transfer switch (sym. 42S). The lights are retracted.

The ARUFOSh-45 lights (sym. 37S and 40S) are designed to illuminate the dials of the measuring instruments and control levers with ultraviolet rays. The dials and levers are covered with a phosphorescent material which reacts temporarily.

The voltage is supplied to the lights from the AZS (sym. 35S) through the rheostats (sym. 38S and 39S). The intensity of the light from the ARUFOSh-45 lights can be changed by these rheostats, which, in addition, can either cut the lights in or out.

The navigation lights - ANO - (sym. 19S, 20S, 21S) are cut in by setting the transfer switch (sym. 16S) to one of the three positions, "high," "medium," "low," depending upon the light intensity required. In this case the voltage supply from the aircraft network is from the AZS (sym. 2S) switch through the transfer switch (sym. 16S) contacts and the resistance (sym. 17S).

The receptacle (sym. 36S) for connecting the portable lights receives its supply from the AZS (sym. 35S) switch.

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The light KLSRK-45 (sym. 1S) provides illumination in the cockpit. Voltage from the aircraft network is supplied the light through the AZS (sym. 34K) switch. A rheostat is provided to change the light intensity in the cockpit, as

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well as to provide a means for cutting the light on and off.

A push button is provided in the event the light is required for only a short period of time. When the button is pressed full voltage from the aircraft network is supplied to the light through the closed contacts.

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21. System for heating storage batteries, the airtight helmet GSh-4M, KKO-3, clocks, PVD and TP-156M

General information

The system is designed to provide a normal operational temperature regime for the storage batteries, to provide against fogging of the window in the airtight helmet, to provide for accurate clock operation, and to prevent the PVD and TP-156 M receivers from icing.

System operation is provided for by the devices given in the table.

No.	Symbol	Name of item	Type	Quantity	Location
1	2	3	4	5	6
1	20T	Switch "ground heating storage batteries," "on-off"	87K	1	Horizontal section, starboard console
2	42T	Relay	TKYe-52PD	1	Relay box, between frames 11-12, port side
3	13T	Heater jacket		1	Is placed on the storage batteries

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1	2	3	4	5	6
4	34E	Fuse	IP-5	1	Frames 9-10, under cockpit floor

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5	35S	Circuit breaker "ARUFOSh" transfer switch lights, heater KKO, AGD"	AZS-5	1	After electrical switchboard, starboard console, cockpit
6	18T	Rheostat	RKO-45	1	Port console, cockpit
7	21T	Push button	204KS	1	same
8	7T	Circuit breaker "heater PVD, clocks"	AZS-10	1	Instrument panel
9	8T	Heater element, clocks AChKh	AChKh	1	Instrument panel, clocks
10	9T	Heater element, PVD	DUAS-8M	1	End of PVD rod
11	11T	Circuit breaker, "TP-156 heater"	AZS-10	1	Instrument panel
12	10T	TP-156M heater element	TP-156M	1	Starboard side fuselage, between frames 3-4

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Electrical system operation

The storage battery 15STsS-45 heater element (sym. 13T) is cut in by setting the switch (sym. 20T) in the "on" position.

When the switch (sym. 20T) is set in the "on" position voltage is supplied to the heater element from the ground supply source through the KPA-4 (sym. 30E), the fuse (sym. 34E), the closed contacts of the transfer switch

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(sym. 20T) and contacts 2-3 and 5-6 in the relay (sym. 12T).

The relay (sym. 12T) operates automatically when the contacts in the thermal switch close as a result of a drop in temperature.

NOTE: The heater jacket has a thermal relay, T-50, which is set to open its contacts at a temperature of 12° ± 2°C.

Heating of the GSh-4M KKO-3 airtight helmet is accomplished by supplying voltage from the aircraft network through the AZS (sym. 35S) switch to the heater element in the helmet, or through the rheostat (sym. 18T) or through the closed contacts of the push button (sym. 21T).

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The filament in the heater element is adjusted by the use of the rheostat, which also is used to either supply full voltage from the aircraft network, or to cut out the supply.

When the push button is pressed rapid heating of the helmet is cut in (full voltage from the aircraft network is supplied to the helmet heating element).

Heating the PVD, the AChKh clocks and the TP-156M dynamic pressure receiver is accomplished by cutting in, respectively, the circuit breakers (sym. 7T, 11T). When the breaker is cut in voltage from the aircraft network is supplied to the PVD heating element (sym. 9T), the AChKh (sym. 8T) heating element, and the TP-156M (sym. 10T) heating element.

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22. Cockpit heating system

General information

The devices contained in this particular system are given in the table.

No.	Symbol	Name of item	Type	Quantity	Location
1	1T	Circuit breaker "Cockpit heat"	AZS-5	1	After electrical switchboard console, cockpit
2	2T	Transfer switch "automatic-hot-cold"	P2NPN-45	1	Horizontal section, starboard console, cabin
3	3T	Temperature regulator	TRTVK-45M	1	Cockpit, frame 11, port
4	14T	Relay block	BRTRTVK-45M	1	Same
5	4T	Electrical air distributor	525 aggregate	1	Lower fuselage, frames 20-22, port

The temperature regulator is designed to automatically maintain the air temperature in the cockpit within fixed limits.

The electrical air distributor is designed to receive air from the engine compressor and to distribute it over the hot or cold ducts, or over both ducts simultaneously.

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The relay block is designed to switch the electrical supply circuits to the electrical air distributor.

Electrical system operation

In order to automatically maintain air temperature in the cockpit within set (with the aid of a dial) limits, the AZS (sym. 1T) is closed and the transfer switch (sym. 2T) is set to the "automatic" position.

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If the air temperature is below the "normal" set on the dial the bimetal helix in the air regulator (sym. 3T), which is in contact with the air in the main duct, is deformed so that the first fixed and the movable contacts close and feeds negative to the relay winding in the block (sym. 14T) through terminals "B" and "D" of the temperature regulator (sym. 3T) plug and terminal "V" of the relay block (sym. 14T) plug. Positive voltage is supplied from the AZS (sym. 1T) through the closed switch (sym. 2T) contacts and terminals "L" and "Zh" of relay block (sym. 14T) plug to the relay windings and contacts. The relay operates and distributes the voltage from the aircraft network to the electric motor in the electrical air distributor (sym. 4T) through closed contacts in the relay block (sym. 14T), terminal "Ye" of the block (sym. 14T) plug, through terminal "A" of the electrical distributor (sym. 4T) plug, the closed contacts of the terminal switch and the winding of the air distributor (sym. 4T) reverser. The electric

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motor begins to run and opens the dampers in the main duct delivering hot air.

If the temperature in the cockpit begins to exceed the temperature set on the dial, the bimetal helix in the air regulator (sym. 3T) is deformed and the movable and second contacts closed and cut in the air distributor (sym. 4T) electric motor through the contracts in the other block relay (sym. 14T). The electric motor turns the damper in the main duct to deliver cool air to the cockpit.

In order to reduce the fluctuations in temperature, the electrical air distributor has a feedback electromagnetic coil which is connected at both ends to the potentiometer in the electrical mechanism for distributing the air

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(sym. 4T). One end of the potentiometer and the feedback coil have voltage from the aircraft network; the other end of the potentiometer has "negative" while the potentiometer slide is connected to the other end of the feedback coil.

The potentiometer slide, which moves with the distribution valve dampers, changes the voltage in the feedback coil. The lower the slide on the potentiometer, the higher the voltage in the coil, and vice versa.

The movable contact in the air regulator (sym. 3T) is, correspondingly, pulled up to the coil core or moved away from it, closing the circuit for cutting in the cold air

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supply and opening the circuit for cutting in the hot air supply, and vice versa.

Thus, the air temperature in the cockpit is automatically stabilized.

If the pilot is not satisfied with the temperature established by the dial on the temperature regulator (sym. 3T), the transfer switch (sym. 2T) can be set to one of the required positions, "cold," or "hot."

In this case the automatic air temperature regulator in the cockpit is cut out and the aircraft network voltage is supplied directly to the air distributor electric motor (sym. 4T) from the transfer switch (sym. 2T) through one of the reverser windings. The motor turns the damper in the main duct to supply either cold or hot air.

When the required temperature has been established the electric motor can be cut out with the transfer switch (sym. 2T).

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23. Seat position control system

General information

No.	Symbol	Name of item	Type	Quantity	Location
1	47M	Circuit breaker "Seat control"	AZS-15	1	After electrical switchboard, starboard console
2	48M	Transfer switch "seat control - up - down"	PN-45M	1	Port console, cockpit
3	49M	Terminal switch	VK2-141	1	Upper section, port rail, seat framework
4	61M	Terminal switch	VK2-141	1	Same
5	45M	Electric motor	MU-100AP	1	Lower transverse girder, seat framework

Seat position control, depending upon the size of the pilot, is carried out by shifting the seat bucket up or down on the guide rails of the seat frame-

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work. Raising and lowering the seat bucket is carried out with the aid of a screw rotated by the MU-100AP motor. Since the motor is reversible the screw can be rotated either way.

Travel of the bucket up or down is limited by the terminal switch mechanisms.

The electrical plug ShR20-PK4NSh8 is installed underneath the seat on the starboard rail of the seat framework and serves to disconnect the circuit supplying the electric motor (in event the seat must be taken out).

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Electrical system operation

When the transfer switch (sym. 48M) is set to the "lower" position (circuit breaker sym. 47M is closed) the supply from the aircraft network is fed to the winding in the electric motor (sym. 45M) reverser through the normally closed contacts of the terminal switch (sym. 49M).

The MU-100AP motor turns left, lowering the seat to the position in which the terminal switches (sym. 49M, 61M) operate.

Terminal switch (sym. 49M) opens the normally closed contacts, interrupting the flow of current to the reverser winding and the motor stops. Terminal switch sym. 61M closes its normally closed contacts, preparing the circuit supplying the reverser winding for

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right rotation of the electric motor.

When the transfer switch (sym. 48M) is set to the "raise" position the supply from the aircraft network is to the motor reverser winding (sym. 45M) through the normally closed contacts of the terminal switch (sym. 61M). The MU-100AP electric motor turns right, raising the seat to the position at which the terminal switches (sym. 61M, 49M) operate.

Terminal switch sym. 61M opens the normally closed contacts, interrupting the current supply to the reverser winding and the motor stops. Terminal switch sym. 49M closes its normally closed contacts, preparing the circuit to supply the reverser winding for left rotation of the motor.

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24. Canopy anti-icing control system

General information

The system is designed to prevent icing of the canopy glass.

System operation is provided for by the devices given in the table.

No.	Symbol	Name of item	Type	Quantity	Location
1	9K	Circuit breaker "fire equip., canopy anti-ice"	AZS-5	1	Switchboard, port console
2	5T	Push button "glass anti-ice"	5KS	1	Port, upper section instrument panel
3	6T	Electro-pneumatic valve	695000/M	1	Fuselage, lower, frames 5-7

Electrical system operation

The system is cut in by the push button (sym. 5T). When the contacts close voltage from the aircraft network is supplied through the closed AZS (sym. 9K) to terminal 1 of the electro-pheumatic valve plug (sym. 6T). The valve operates and compressed air is started into the tank in the anti-icing system. Air pressure in the tank ejects alcohol which is sprayed on the canopy glass through a manifold.

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25. Aerial navigation equipment system

General information

Included in the aerial navigation equipment system are:

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No.	Symbol	Name of item	Type	Quantity	Location
1	2	3	4	5	6
1	1N	Circuit breaker, "AGD"	AZS-5	1	Forward electrical switchboard, starboard console, cockpit
2	2N	Converter	PT-500Ts	1	Upper equipment hatch, frames 4-5
3	3N	Indicator	AGD-1	1	Instrument panel
4	4N	Fuse "converter PT-500Ts for KSI, AGD, VRD"	IP-50	1	Power unit, starboard side, frames 12-13
5	6N	Turn indicator	EUP-53	1	Instrument panel
6	7N	KSI matching mechanism	MS-1	1	Upper equipment hatch, frames 3-4, starboard
7	8N	KSI gyroscope aggregate	GA-2	1	Upper equipment hatch, frames 3-4

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8	9N	KSI indicator	UGR-4U	1	Instrument panel
9	10N	Circuit breaker "KSI"	AZS-5	1	Forward electrical switchboard, starboard console, cockpit
10	11N	KSI correction mechanism	KM-3	1	Starboard side fuselage, frames 10-11
11	12N	Correction switch	VK-58R6	1	Cockpit, port side, frames 6-7
12	13N	KSI amplifier	U-12	1	Cockpit, frames 6-7
13	14N	KSI induction transmitter	ID-2	1	Tail fin
14	15N	KSI matching push button	5KS	1	Instrument panel

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1	2	3	4	5	6
15	16N	Relay	TKYe-53PD	1	Relay box, upper instrument hatch, frame 4, starboard
16	17N	Relay	TKYe-53PD	1	Same
17	18N	KSI amplifier	U-18	1	Cockpit, port side, frames 6-7
18	19N	Relay	TKYe-21PD	1	Relay box, upper equipment hatch, frame 4, starboard
19	20N	Fuse	SP-2	1	Upper equipment hatch, starboard side, frames 4-5

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20	21N	Fuse	SP-2	1	Upper equipment hatch, starboard side, frames 4-5
21	22N	Fuse	SP-5	1	same
22	23N	Fuse	SP-5	1	same
23	24N	Gyro transmitter	AGD-1	1	Upper equipment hatch, port side, frames 5-6
24	25N	KSI control panel	PU-2	1	Upper equipment hatch, port side, frames 3-4
25	30N	Relay block	BR-4	1	Starboard side, frames 4-5
26	(blur)	Circuit breaker "indicators for generator, EUP, (blur)"	AZS-5	1	Cockpit, port console, vertical section
27	35S	Circuit breaker "check display lights, fuel remaining; trim effect indicator"	AZS-5	1	Cockpit, after electrical switchboard, starboard console

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The purpose, the make up, as well as the electrical supply for the fighter plane course system KSI, the gyrohorizon AGD-1, and the electrical turn indicator EUP-53, are described in the chapter titled "Instrumentation" in the present volume.

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26. Armament system

General information

The following units are contained in the armament system:

No.	Symbol	Name of Item	Type	Quantity	Location
1	2	3	4	5	6
1	1P	Circuit breaker, "Sight, sight heater"	AZS-20	1	Cockpit, Starboard forward electrical switchboard
2	2P	Circuit breaker "Sight"	AZS-10	1	same
3	3P	Relay for cutting in PO-500A for "SS" supply	TKYe-52PD	1	Lower equipment hatch, radio relay box, frames 8-9, starboard side
4	4P	Filter	F-14A	1	Cockpit, frames 10-11, on starboard seat rail
5	5P	Distribution box (block No. 5)	ASP-5ND	1	Upper special equipment hatch, frames 5-6, port side
6	6P	Null gyroscope amplifier (block No. 4)	ASP-5ND	1	same
7	7P	Automatic altitude input (block No. 6)	ASP-5ND	1	Upper equipment hatch, frames 5-6, along axis of symmetry

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1	2	3	4	5	6
8	8P	Damping button	204KS	1	Cockpit, on control stick
9	9P	Electronic relay block (block No. 8)	ASP-5ND	1	Upper special equipment hatch, frames 5-6, starboard side
10	10P	Computer (block No. 2)	ASP-5ND	1	Upper special equipment hatch, frames 3-4, port side
11	11P	Null gyroscope (block No. 3)	ASP-5ND	1	Upper special equipment hatch, frames 2-2A, along axis of symmetry
12	12P	Sight head (block No. 1)	ASP-5ND	1	Cockpit, fram 7b, above instrument panel
13	13P	Voltage stabilizer (block No.9)	SN-4 of ASP-5ND complex	1	Cockpit, frames 6-7, on floor
14	14P	Fuse in "SS" AC circuit	SP-5	1	Radio relay box, frames 8-9, under cockpit floor
15	15P	Manual range input potentiometer	ASP-5ND	1	Cockpit, throttle lever
16	16P	Sight transfer switch panel	ASP-5ND	1	Cockpit, block No. 1, above instrument panel

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17	17P	Circuit breaker, "gun, SS, RS, FKP".	AZS-5	1	Cockpit, starboard after electrical switchboard
18	18P	Firing control button	204KS	1	Aircraft control stick
19	19P	Circuit breaker "FKP"	AZS-5	1	Cockpit, starboard forward electrical switchboard

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1	2	3	4	5	6
20	24P	Transfer switch for range only radar modes and firing circuits "RS, "Gun-SS"	VT3602006 SP	1	Cockpit, vertical section, port console
21	25P	Circuit breaker "Gun"	AZS-10	1	Cockpit, starboard forward electrical switchboard
22	26P	Switching relay for control of gun firing and "SS" launching	TKYe-21PD	1	Relay box behind pilot's seat, frame 11
23	27P	Electric trigger gun	-	1	Gun
24	28P	Relay for cutting in gun and FKP circuits	TKYe-52PD	1	Relay box on instrument panel, frame 6
25	37P	Gun ready signal light	SLTs-51 (red)	1	Instrument panel, middle section
26	38P	Gun ready signal relay	TKYe-21PD	1	Relay box behind instrument panel, frame 6

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27	39P	Gun reload button	5KS	1	Port upper section instrument panel
28	40P	Electropneumatic valve for reloading gun	EK-48	1	Frames 14-15, lower, starboard side
29	41P	Relay for cutting in RS and FKP circuits	TKYe-52PD	1	Relay box behind pilot seat, frame 11
30	42P	Gun camera	SSh-45-1-100-OS	1	Cockpit, on sighthead
31	43P	Timing mechanism	VM-2	1	Cockpit, starboard side sight head
32	44P	SIV-52 supply block	SIV-52	1	Cockpit, behind pilot seat, starboard
33	46P	Circuit breaker "SIV"	AZS-5	1	Cockpit, starboard forward electrical switch board

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1	2	3	4	5	6
34	1B	Circuit breaker "RS, APU suspension indicator"	AZS-5	1	Cockpit, starboard after electrical switchboard
35	(blur)	Relay for cutting in FKP circuit	TKYe-53PD	1	Relay box behind pilot seat, port, frame 11
			Page 216		
38	5B	Suspended tank lock	BDZ-56-Ye	1	Fuselage pylon, frames 17-18
40	7B	Suspended tank signal light	SLTs-51 (green)	1	same
41	8B	Beam pylon	BDZ-60-21U	1	Starboard wing
42	9B	Circuit breaker "Emergency drop RS, tank, APU. Emergency launch SS"	AZS-20	1	Cockpit, starboard, after electrical switchboard
43	10B	Push Button for dropping tank	5KS	1	Port section instrument panel
44	11B	Beam pylon	BDZ-60-21U	1	Port wing
45	12B	Signal light, zero position PUS	SLTs-51 (green)	1	Cockpit, starboard forward electrical switchboard
46	13B	Signal light, zero position PUS	SLTs-51 (green)	1	same
47	14B	Circuit breaker "RS"	AZS-10	1	Cockpit, starboard forward electrical switchboard
			Page 217		
48	15B	RS salvo transfer switch	VT3602020SP	1	Port console, vertical section
49	16B	RS fire control instrument	PUS-36	1	Port wing, tips nos. 14-15 wing ribs
50	17B	RS fire control instrument	PUS-36	1	Starboard wing, tips nos. 14-15 wing ribs

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1	2	3	4	5	6
51	19B	"SS" audio signal volume regulator	SPO-0.5-VT-33K-Sh13	1	Port console
52	20B	Relay for blocking RS, SS launch because of landing gear	TKYe-53PD	1	Relay box, frames 11-12, port side
53	21B	Relay for cutting in overload signal	TKYe-21PD	1	Relay box behind instrument panel, frame 6
54	22B	Push button, emergency launch "SS"	204KS	1	Instrument panel
55	23B	Push button, emergency dump RS, APU-SS	205KS	1	Port upper section instrument panel
56	24B	Signal light indicating suspension RS, APU on port wing	SLTs-51 (green)	1	Instrument panel, middle electrical switchboard
57	25B	Signal light indicating suspension RS, APU on starboard wing	SLTs-51	1	same
58	26B	Altitude signal device	VS-14500	1	Equipment hatch, frames 2-2a, port

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59	27B	Overload signal light	SLTs-51 (red)		Above instrument panel on sight bracket
60	28B	Circuit breaker "SS heat"	AZS-20	1	Cockpit, starboard forward electrical switchboard
61	29B	Circuit breaker "SS filament"	AZS-10	1	Cockpit, starboard forward electrical switchboard
62	30B	Circuit breaker "SS launch"	AZS-10	1	same
63	31B	Signal light, suspension port SS"	SLTs-51 (green)	1	Instrument panel, upper starboard panel
64	32B	Signal light, suspension starboard SS"	SLTs-51	1	same

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1	2	3	4	5	6
65	33B	"SS" Launch switch "Salvo - single"	87K	1	same
66	34B	Relay for transferring overload signal circuits	TKYe-21PD	1	Relay box behind pilot seat, port, frame 11
67	35B	Overload mechanism	MP-28A	1	Back fairing of fuselage, frames 11-12
68	36B	Transfer switch, separate launch SS	2PPN-45	1	Instrument panel, upper starboard panel
69	37B	Relay for cutting in SS launch circuits	TKYe-52PD	1	Relay box behind pilot seat, port, frame 11
		Page 219			
70	40B	APU suspension lock	DZ-57	1	Port wing pylon
71	41B	APU suspension lock	DZ-57	1	Starboard wing pylon
74	6R	Circuit breaker "range only radar"	AZS-5	1	Cockpit, starboard forward electrical switchboard
75	15R	Converter for supplying ASP, SIV, SS	PO-500A	1	Upper equipment hatch, frames 4-5, starboard side
76	20R	Fuse	SP-5	1	Relay box, frames 8-9, starboard side, bottom of fuselage
77	25R	Signal light, withdraw from attack	SLTs-51	1	Above instrument panel, on sight bracket
78	26R	Signal light, permissible range	SLTs-51 (green)	1	same
79	47R	Fuse	SP-5	1	Relay box, frames 8-9, starboard side, bottom of fuselage
80	48R	Relay for cutting in SIV-52	TKYe-52PD	1	same

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1	2	3	4	5	6

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81	24S	Relay for checking signal lights	TKYe-56PD	1	Relay box behind instrument panel, frame 6
82	33E	Relay for cutting out power consumers	TKYe-53PD	1	Cockpit, frames 6-7, starboard side
83	17E	Relay for cutting in power consumers	TKD-203DT	1	same

The aircraft network serves the armament system with electricity as well. The armament system consists of the gun and rocket installations, as well as the sight, the range only radar infrared viewfinder and the gun camera.

Distribution of electric power from the aircraft network busbars to the consumers in the armament system is done in the following way:

-the gun, rocket and gun camera circuits are supplied from bus number 4 on the forward electrical switchboard of the starboard console through the respective circuit breakers: gun (sym. 25P); "RS" (sym.14B), "SS heater" (sym. 28B), "SS filament" (sym. 29B), "SS launch" (sym.30B), FKP (sym. 19P);

- the aggregates used for emergency jettisoning of the "RS" and "APU" blocks, and for emergency launching of the "SS" are supplied from bus number 2 on the forward electrical switchboard of the starboard console through the "emergency jettison" (sym. 9B) circuit breaker;

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- the aggregates for jettisoning the RS and the tank, and the firing button are supplied from bus number 3 of the after electrical

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switchboard of the starboard console through the "RS, APU suspension Indicator" (sym. 1B) and the "gun, RS, FKP" (sym. 17P) circuit breakers;

- the sight and the infrared viewfinder SIV are supplied from bus number 4 of the forward electrical switchboard of the starboard console through the "sight heater, sight" (sym. 1P), "sight" (sym. 2P) and "SIV" (sym. 46p) circuit breakers, respectively.

The 115 volts alternating current for the sight, SIV and the EPU-13 in the K-13 system is supplied from the PO-500A (sym. 15R) converter when the AZS (sym. 1P, 2P, 46P, 30B) are cut in.

The switching gear in the armaments electrical system is the common firing button (sym. 18P) for all types of armament and the transfer switch on the sight control panel (block number 1), the setting of which determines the type of armament, as well as:

- the relay (sym. 28P) for cutting in the electric trigger (sym. 27P) for the NR-30 gun, the electric motor for the gun camera SSh-45-1-100-OS (sym. 42P), through the VM-2 timing mechanism (sym. 43P);

- the relay (sym. 26P) for switching the "SS" firing and gun control circuits;

- the transfer switch (sym. 24P) - "RS - gun" -"SS;"

- the relay (sym. 38P) for indicating readiness of gun to fire;

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- the push button (sym. 39P) for reloading the gun;

- the relay (sym. 41P) for cutting in the "RS" and the SSh-45-1-100-OS;

- the relay (sym. 20B) for blocking "RS" and "SS" launching because of the forward landing gear strut;

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- the relay (sym. 37B) for cutting in the "SS" launch circuits;

- the push button (sym. 23B) for effecting emergency jettisoning of the "RS" and APU-13;

- the push button (sym. 10B) for cutting in the circuit to jettison the tank;

-the push button (sym. 22B) for emergency "SS" launch.

A more detailed description of the MIG-21F (with the K-13 system) armament, and of its electrical circuits providing for operation of the aggregates in the armament system, is given in book II on "Armament."

Chapter II

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Radio Equipment

I. General information

1. Aircraft radio equipment composition

The radio equipment in the aircraft consists of the RSIU-5G ultra-short wave radio set for communications, the ARK-10 type automatic, medium wave radio compass, the type MRP-56P marker radio receiver, the type RV-UM low elevation radio altimeter, the SRO-1 aircraft responder in the radar recognition system, and the SRD-5MK range only radar.

The schematic showing the placement of the radio equipment in the aircraft is given in figure 26. The schematic showing the placement of the radio equipment with respect to the framing is given in figure 27. The upper equipment compartment is shown infigure 28.

2. Tasks accomplished by the aircraft radio equipment

The radio equipment installed in the aircraft provides:

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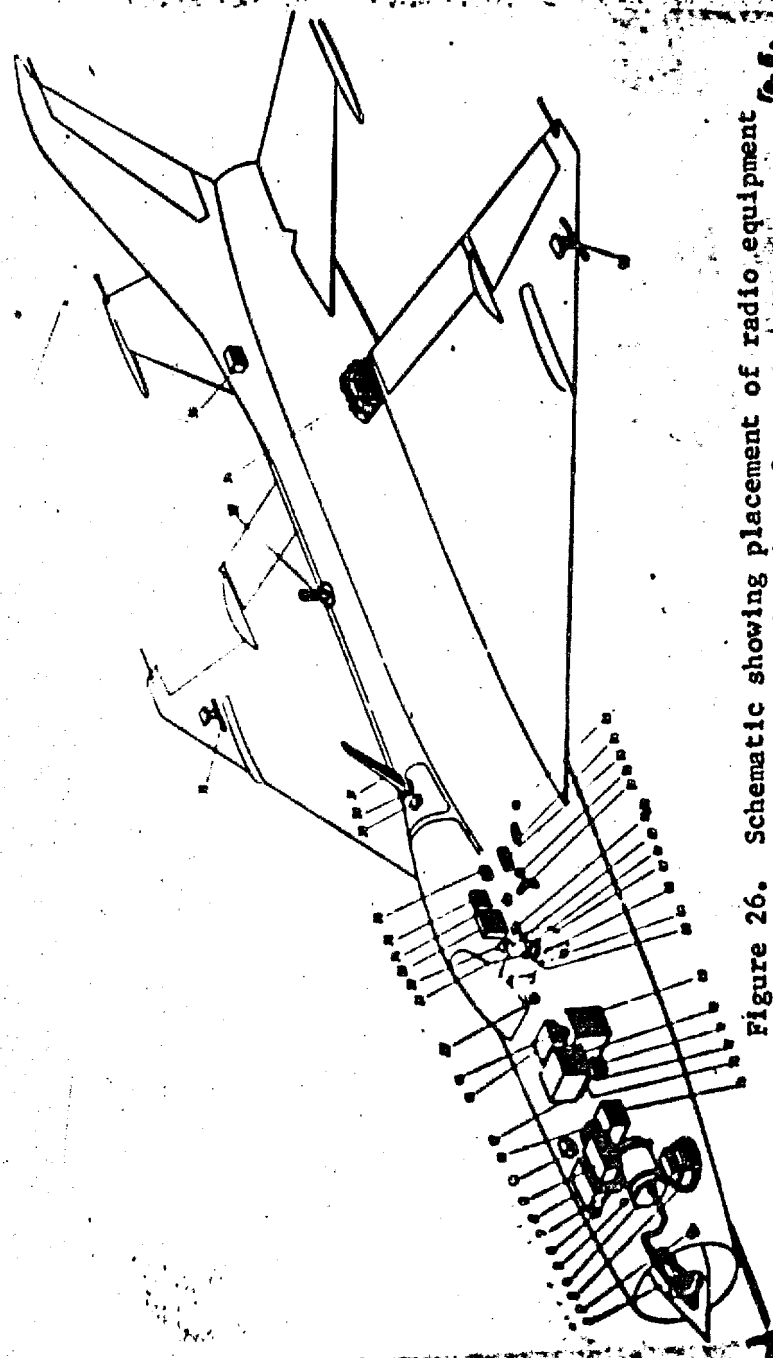

Figure 26. Schematic showing placement of radio equipment in the aircraft (U).

Рис. 26. Схема размещения радиооборудования на самолете.

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1. Two-way radio telephone communications between the aircraft and ground stations (over the RSIU-5G ultra-short wave radio set).

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Figure 26. Placement of radio equipment

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Specifications for the schematic showing placement of radio equipment (fig. 26)

Block No.	Position number on schematic	Block name	Location
1	2	3	4
		RSIU-5G	
1	12	Transceiver with supply block - blocks A, B, V	Upper equipment compartment, between frames 4 and 5
2	55	Control panel, P-1	Cockpit, vertical section port console, between frames 8 and 9
3	57	Button for cutting the radio set on for transmit operation	Cockpit, port console, aircraft control stick handle
4	31	Combined whip antenna, RSIU-5G and ARK-10	After fixed section of canopy, between frames 13 and 14
5	30	Separation filter AF-1, for combined whip antenna for RSIU-5G and ARK-10	After fixed section canopy, between frames 13 and 14
6	54	Amplifier UK-21, series "B"	Cockpit, port console, frame 10
7	53	Separation transformer	Cockpit, port, between frames 10 and 11

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1	2	3	4
		Page 226	
		ARK-10	
1	15	Receiver	Upper equipment compartment, between frames 5 and 6
2	10	Supply block	Upper equipment compartment, starboard, between frames 3A and 4
3	23	Control panel	Cockpit, middle vertical panel of starboard console, between frames 8 and 9
4	56	Remote wave transfer switch	Cockpit, vertical section port console, between frames 8 and 9
5	61	Course indicator UGR-4U (in the KSI complex)	Cockpit, instrument panel
6	24	Tuning indicator	Cockpit, horizontal section starboard console
7	60	Transfer switch "short-long"	Cockpit, instrument panel
8	-8	All-purpose automatic device for UAP-1 transfer switch	Cockpit, behind instrument panel, starboard
11	23	Antenna amplifier	After fixed section canopy, frame 13
12	3	Directional loop antenna block	Nose section fuselage, underneath, between frames 2 and 3
13	31	Combined (nondirectional) whip antenna, RSIU-5G and ARK-10	After fixed section canopy, between frames 13 and 14
14	30	AF-1 filter for combined whip antenna RSIU-5G and ARK-10	After fixed section canopy, between frames 13 and 14

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1	2	3	4
		Page 227	
15		Equivalent feeder (5m) in the directional antenna channel	Upper equipment compartment, starboard, between frames 2A and 3
16		Equivalent feeder (18M) in the combined whip antenna channel for the RSIU-5G and ARK-10	After fixed section canopy, between frames 13 and 14
10	65	"ARK-BPRS" indicator light	Cockpit, instrument panel, port
		RV-UM	
1	74	Transceiver - PP-U block	Upper equipment compartment, between frames 3 and 4
2	43	Transmitting antenna	Port wing, underneath, between tips of wing ribs 23 and 24
3	75	Receiving antenna	Starboard wing, underneath, between tips of wing ribs 23 and 24
4	62	Altitude indicator, UV-57	Cockpit, instrument panel, port
5	63	"Dangerous altitude" signal light	Cockpit, instrument panel, port
6	64	Transfer switch for dangerous altitude, PSV-U	Cockpit, instrument panel
7	73	Filter VChF-3	Upper equipment compartment, between frames 4 and 5

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1	2	3	4
		Page 228	
		MRP-56P	
	36	Receiver, MRP-56P	Tail fin fairing, between frames 33 and 33A
	34	Intrafuselage antenna	Tail section fuselage, between frames 30 and 31A, underneath
	26	Indicator block	Cockpit, starboard console, frame 11
	21	"Marker" signal light	Cockpit, instrument panel, T-4 signal panel

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SRO-1

1	/2	3	4
2	68	Transceiver	Upper equipment compartment, between frames 5 and 6
3	25	Code panel	Cockpit, vertical section starboard console, frame 9
4	72	Inertial contactor	Upper equipment compartment, between frames 4 and 5, port side
6	59	Exploder push button	Cockpit, horizontal section of starboard console
1	32	Antenna	Nose section fuselage, between frames 21 and 22 (sic), on top
5	16	Exploder circuit check panel	Upper equipment compartment, between frames 5 and 6, port side.
7	58	Transfer switch "Distress"	Cockpit, horizontal section, board console
		SRD Range Only Radar	
1	1	Combination antenna and waveguide tract	Forward section fuselage, cone
2	4	Transceiver block RB6-2M	Upper equipment compartment, between frames 2A and 3
3	8	Receiver-range meter block- RB6-3 block	Upper equipment compartment, between frames 2A and 3, starboard
4	9	Supply block - block RB6-4	Upper equipment compartment, between frames 2A and 3, port.
5	7	Speed block - block RB6-5	Upper equipment compartment, between frames 2A amd 3

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1	2	3	4
		Page 230	
6	6	Check and adjustment panel - K-6 block	Upper equipment compartment, between frames 2A and 3, starboard
7	11	Comparator block - K-8 block	Upper equipment compartment, between frames 2A and 3, port
8	70	Permissible range computer, VRD-2A	Upper equipment compartment, between frames 3 and 4, port
9	22	Range indicator, UD-1	Cockpit, instrument panel
10	71	Air speed transmitter, DVS-5	Upper equipment compartment, between frames 3 and 4, port
11	2	Temperature receiver, P.5	Lower equipment compartment, frame 2, underneath
12	22	"Permissible range" signal light	Cockpit, instrument panel
13		"Withdraw from attack" signal light	Cockpit, instrument panel
16	5	Service plug	Upper equipment compartment, between frames 2 and 2A

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Figure 27. Schematic of placement of radio equipment in the aircraft with respect to framing

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Figure 28. Upper equipment compartment

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Figure 28. Upper equipment compartment

1. Service plug for range only radar.

2. Speed block - block RB6-5 - range only radar

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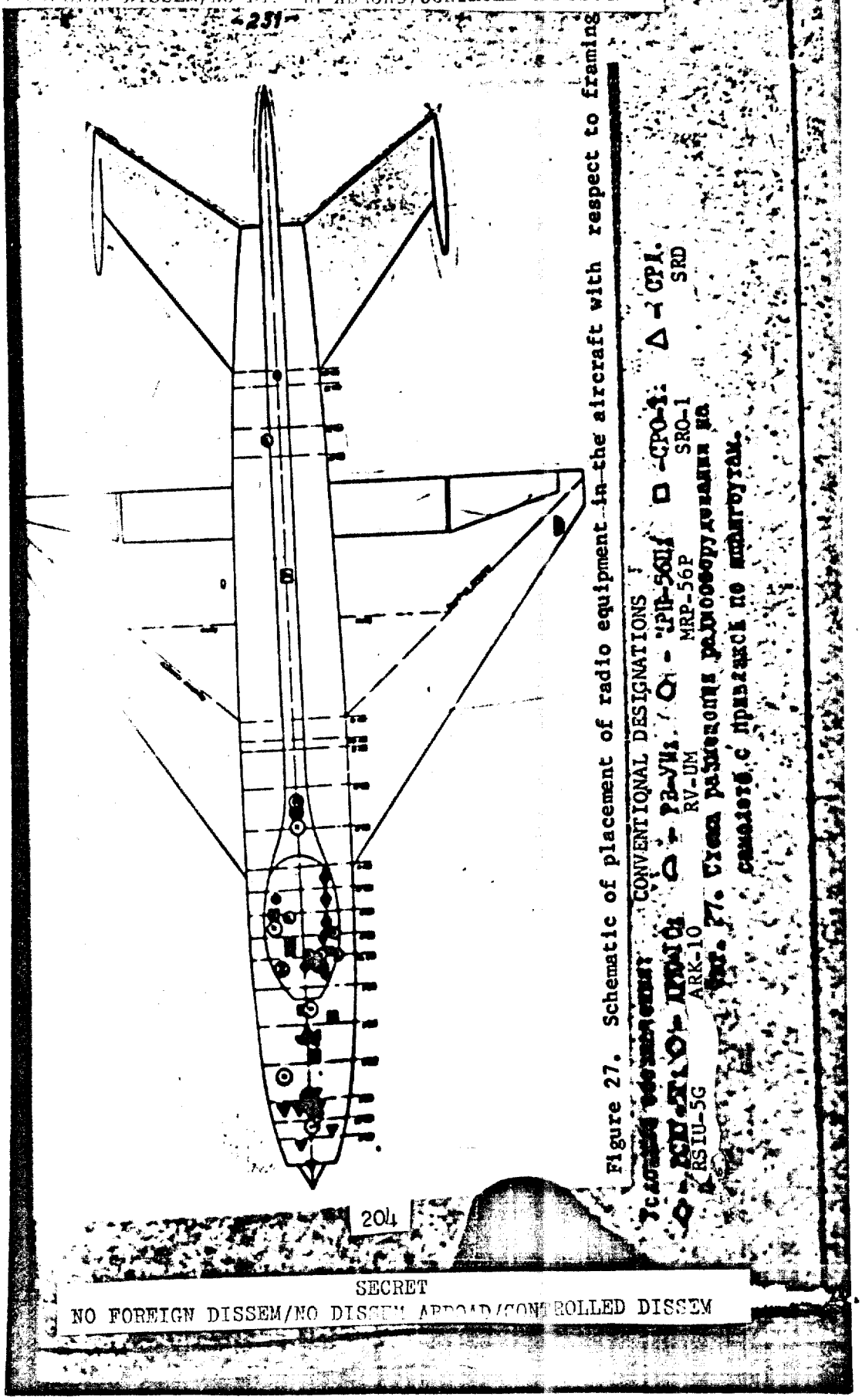

Figure 27. Schematic of placement of radio equipment in the aircraft with respect to framing

CONVENTIONAL DESIGNATIONS

- ARK-10
- RSIU-5G
- RV-UM
- MRP-56P
- SRO-1
- SRD

Рис. 27. Схема размещения радиооборудования на самолете с привязкой по шпангоутам.

SECRET
NO FOREIGN DISSEM/NO DISSEM ABROAD/CONTROLLED DISSEM

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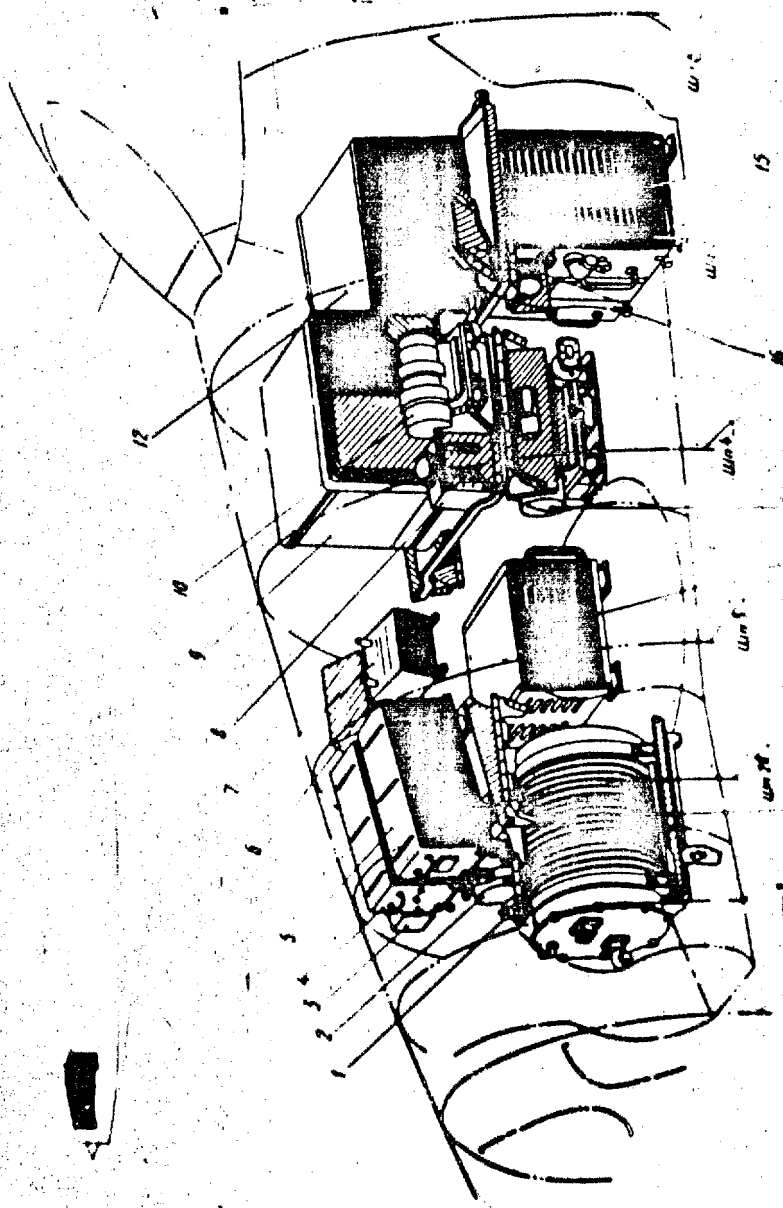

Figure 28. Upper equipment compartment

SECRET
NO FOREIGN DISSEM/NO DISSEM ABROAD/CONTROLLED DISSEM

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3. Check and adjustment panel - block K-6 - range only radar.

4. Reciever-range meter block - block RB6-3 - range only radar.

5. Supply block - block RB6-4 - range only radar.

6. Supply block for automatic radio compass type ARK-10.

7. Comparator block - block K-8 - range only radar.

8. Inertial contactor for the responder in the radar recognition system, SRO-1.

9. Transceiver and supply block - block ABV - ultra-short wave radio set for communications.

10. Permissible range computer VRD-2A of range only radar.

12. Transceiver of automatic radio compass type ARK-10.

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15. Transceiver of aircraft responder SRO-1.

16. Panel installation for checking the exploder circuit in the aircraft responder SRO-1.

17. DVS-5 air speed transmitter for range only radar.

18. Transceiver of radio altimeter for low altitudes, type RV-UM.

19. Transceiver - block RB6-2M - range only radar.

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(TN: the following text is a continuation of that interrupted on page 223)

2. Piloting the aircraft in accordance with homing radio, broadcasting radio stations, and radio beacons (automatic medium-wave radio compass type (ARK-10)

3. Signalling the passage of the aircraft over a radio beacon marker (marker radio receiver installation type (MRP-56P)

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4. Determination of the true flight altitude of the aircraft above the earth's surface and signalling with sufficient warning the given "dangerous" altitude (radio altimeter for low altitudes, typr RV-UM).

5. Provide answering coded signals to aricraft, ground and ship-board interrogating devices (aircraft responder in the radar recognition system, SRO-1).

6. Automatic and continuous determination of distance to target, as well as relative target speed; delivery to the sight computer mechanism of voltages which are proportional to fixed values. Determination of the instant for effective launch of the K-13 "air-air" homing rockets (aircraft range only radar).

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In order to reduce radio interference and to provide for reliable operation of the installed radio equipment the aircraft has static electricity dischargers on the wing tips, the stabilizer and tail fin. All the large units and parts in the aircraft are bonded.

The antenna location schematic is shown in figure 29.

The schematic showing the location in the cockpit of instruments for checking and controlling radio equipment is given in figure 30.

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Figure 29. Antenna location schematic

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Figure 30. Schematic showing the cockpit location of instruments for radio equipment control and checking

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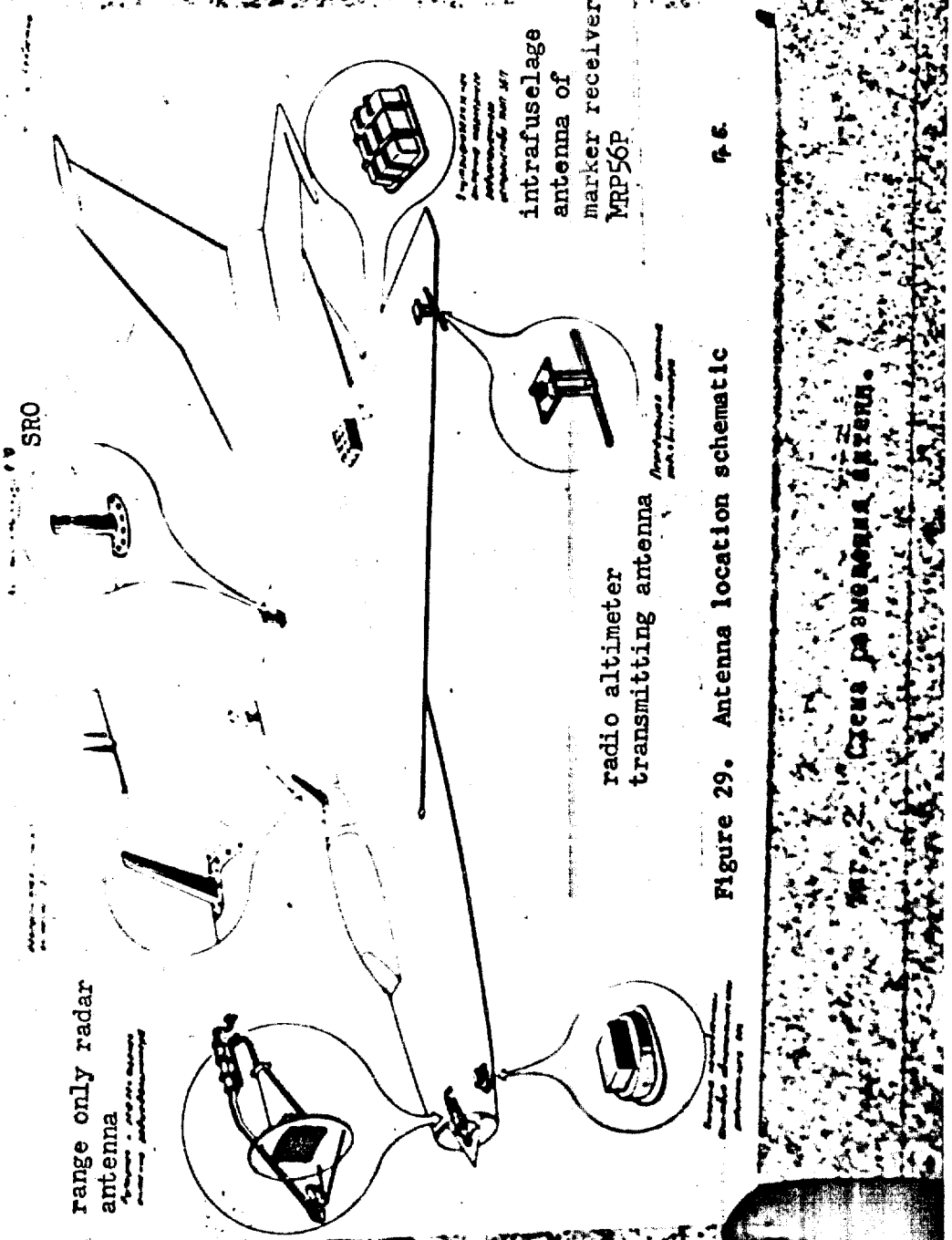

Figure 29. Antenna location schematic

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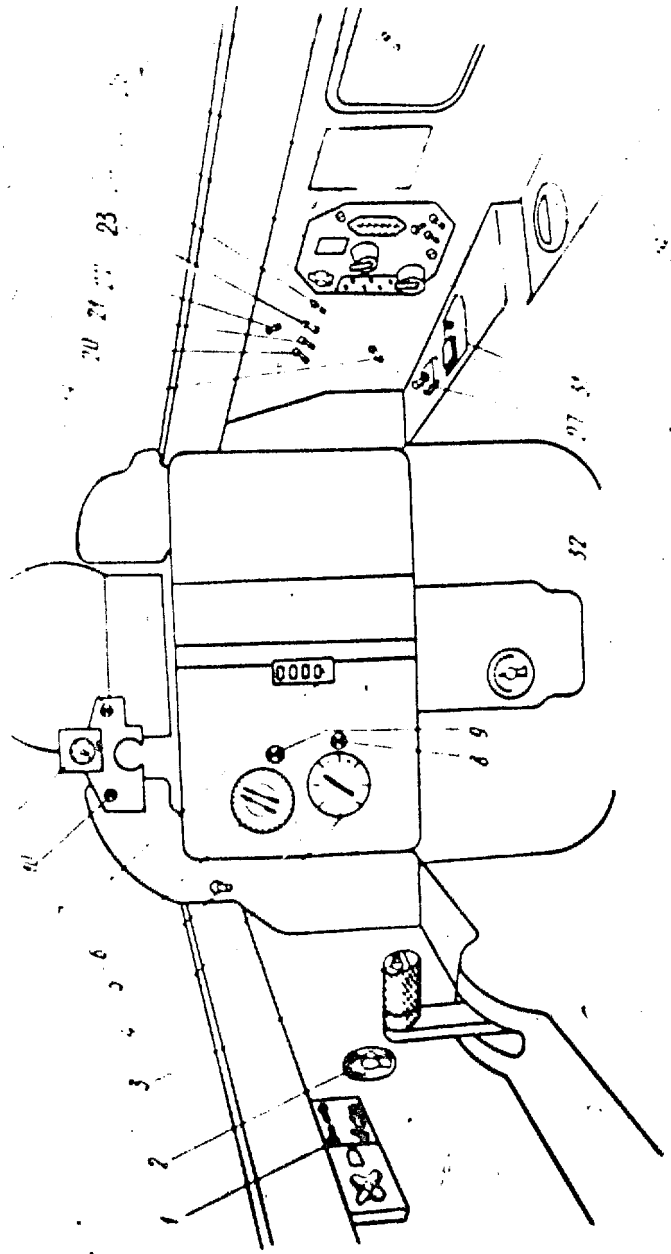

Figure 30. Schematic showing cockpit location of instruments for ~~aircraft~~ and radio equipment control and checking

Расположение в кабине приборов контроля управления радиооборудованием самолета.

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Figure 30. Schematic showing cockpit location of instruments for radio equipment control and checking

1. P-1 control panel for communications radio set.
2. Remote wave transfer switch for ARK-10 automatic radio compass.
3. Push button for cutting in the RSIU radio set to transmit.
4. UV-57 altitude indicator of the RV-UM radio altimeter.
5. "Short-Long" ARK-10 transfer switch.
6. UGR-4U course indicator (of the KSI complex) ARK-10.
7. T-4 indicator panel.
8. Dangerous altitude indicator light of RV-UM radio altimeter.
9. "ARK-BPRS" signal light.
10. "Withdraw from attack" signal light, range only radar.
11. UD-1 range indicator, range only radar.
12. "Permissible range" signal light, range only radar.
19. "SRD" circuit breaker.
20. "Marker, RV-U" circuit breaker.
21. "Radio set" circuit breaker.
22. "PO-750," "RV-U, MRP" cutout circuit breaker.
23. "SRO" circuit breaker.
24. "Emergency converter transfer" circuit breaker.
25. ARK-10 control panel.
26. Responder control panel, SRO-1 radar recognition system.
27. SRO-1 "Distress" transfer switch.

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28. "ARK" circuit breaker.

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29. ARK-10 tuning indicator.

31. SRO-1 "Exploder" push button.

32. PSV-U dangerous altitude transfer switch, RV-UM radio altimeter.

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II. Communications System

The RSIU-5G Ultra-Short Wave Communications Radio Set

1. Purpose

The RSIU-5G ultra-short wave receiver-transmitter is designed to carry on two-way radio telephone communications between the aircraft and communication stations on the ground, as well as between aircraft.

2. Composition

The RSIU-5G communications radio set installed in the aircraft includes:

1. transceiver and supply block (blocks A, B, V);

2. P-1 control panel;

3. push button for cutting in the radio set to transmit;

4. combination whip antenna for RSIU-5G and ARK-10;

5. AF-1 filter (separation), for the combined whip antenna for the RSIU-5G and ARK-10;

6. UK-2M amplified, series "B";

7. separation transformer;

8. Plug with locking screws;

9K - 17K. cable runs and feeders.

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The schematic showing the location, and the manner in which the blocks

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in the ultra-short wave radio set for communications are connected in the aircraft, is given in Figure 31.

3. Brief technical data and methods of carrying on communications

The ultra-short wave receiver-transmitter radio set provides for carrying on two-way radio telephone communications in the 2 - 3 meter wave band (150 - 100 megacycles). The communications waves are uniformly distributed over the band indicated and are stabilized by quartz crystals installed inside the AB block. Quartz crystal stabilization ensures the possibility of establishing communications without searching and carrying on such communications without the need for making fine tuning adjustments.

For operational purposes the set is tuned preliminarily on the ground to a definite number of previously selected communications channels, any one of which can be used in flight. The RSIU radio set is capable of operating against the background of high aircraft noises.

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Used with the radio set for carrying on communications is either the GSh-4M sealed helmet with TA-56M headphones and DEMSh-1 microphone (the transfer switches on the UK-2M, Series "B" amplifier in the "GSh" and "M" positions) or the helmet phone with LA-5 throat phones and TA-56M headphones (the transfer switches on the UK-2M, Series "B" amplified in the "KM" and "L" positions).

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Figure 31. Schematic showing the connections, and the location in the aircraft, of blocks in the ultra-short wave radio set used for communications.

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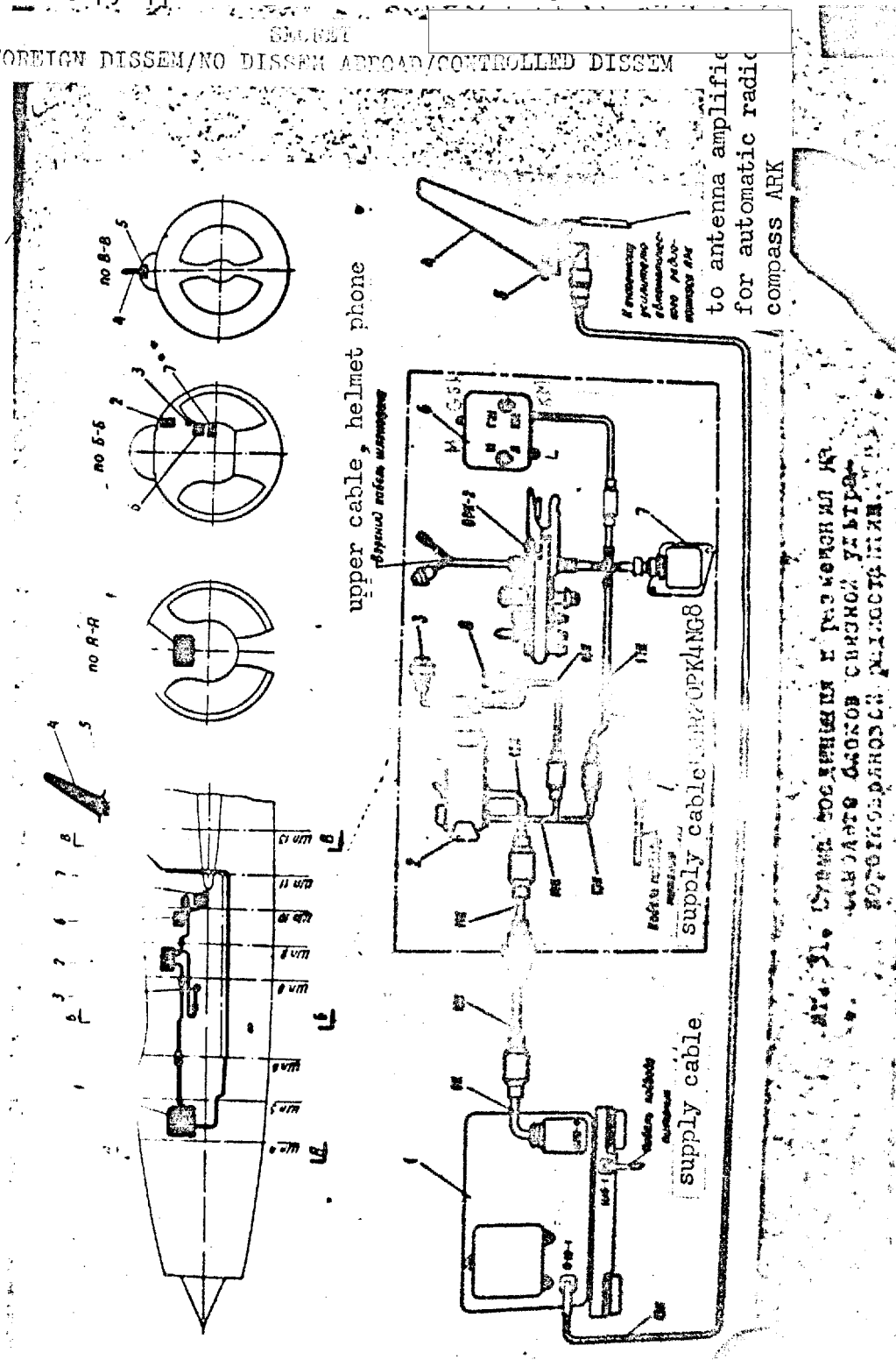

Figure 31. Schematic showing the connections, and the location in the aircraft, of blocks in the ultra-short wave radio set used for communications.

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1. Transciever with ABV supply block.

2. P-1 control panel.

3. Push button for transmit mode for the radio set.

4. Combination whip antenna for RSIU and ARK.

5. AF-1 filter (separation) for combination whip antenna for RSIU and ARK.

6. UK-2M amplified, series "B"

7. Separation transformer.

8. Plug with locking screws.

9K - 17K. Cable runs and feeders.

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The UK-2M amplifier, series "B," is set to match the parameters of the DEMSh-1 microphone in the GSh-4M sealed helmet with the input of the transceiver of the radio set. This is provided for by setting the UK-2M amplifier transfer switch to the "M" and "GSh" position. The UK-2M amplifier does not function in the "L" and "KM" positions. At the same time, the throat microphone circuits in the helmet phone are connected directly to the input of the radio set's transceiver.

Figure 32 is aschematic showing the connections of the helmet phone or the GSh-4M sealed helmet to the P-1 control panel for the radio set, as well as the electrical cable schematic.

The P-1 control panel of the communications radio set permits connecting either the receiver output, the automatic radio compass output, or the output of the automatic radio compass in series with the receiver for

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simultaneous listening, to the telephone in the helmet phone circuit (or the GSh-4M sealed helmet).

The noise suppressor in the radio set eliminates the need to listen to the noise and interference which might come through during standby reception, that is, when there is no signal carrier frequency at the receiver input.

When the noise suppressor is cut in the receiver tract automatically opens up with the advent of such signal carrier frequency.

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Figure 32. Schematic showing the connection of the helmet phone or the sealed helmet to the P-1 control panel for the radio set and the electric cable schematic

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3. Push button for cutting the radio set in to transmit.

6. UK-2M amplified, series "B"

7. Separation transformer.

8. Plug with locking screws.

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It closes (cuts out) when the signal carrier frequency disappears. Operation with the noise suppressor cut in results in some reduction in the range for the set (receiver range is reduced).

The radio set used for communications purposes provides for the following cycle of operations when forced air cooling (forced scavenging of the hermetically sealed casing of block A, B, V) is present: "transmit" 1 minute, "receive" 3 minutes; standby reception can be obtained over a 24 hour period. Should it be necessary to "transmit" for as long as 20

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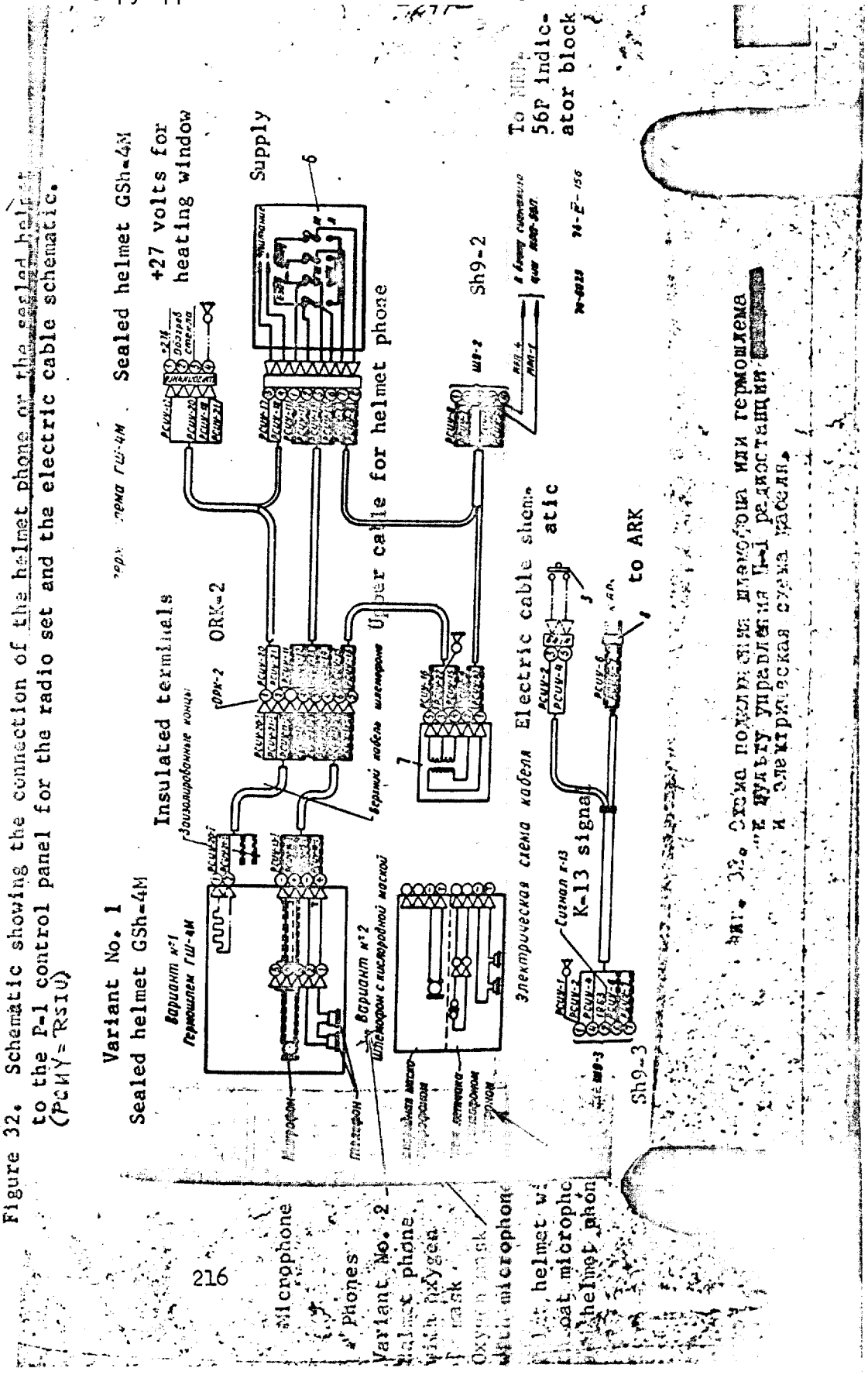

Figure 32. Schematic showing the connection of the helmet phone or the sealed helmet to the P-1 control panel for the radio set and the electric cable schematic.

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minutes, the following 30 minutes must be used as a cooling interval.

With normal airtightness for the transceiver (blocks A, B, V) operation at altitudes of up to 25,000 meters is ensured for the communications radio set.

When operating with a ground station of the RAS-UKV type the communications radio provides a range for two-way radio communications at full power (on the order of 18-20 watts) of at least 350 kilometers at flight altitude of 10,000 meters; when operation is between aircraft the radio provides a range for two-way radio communications of at least 120 kilometers at flight altitudes of from 500 meters up. For lower power (on the order of 3 watts) the ranges indicated are correspondingly reduced 2.5 times.

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4. Cooling the transceiver in the radio set

In order to ensure normal operation of the radio set, forced scavenging of the hermetically sealed casing of the transceiver is used. The air forced through the casing is at a temperature of not more than +50°C.

Figure 33 shows the arrangement for transceiver scavenging.

Air is drawn in from the port duct through a cutoff valve (sym. 9) and a hose (sym. 8) and is supplied to the Pi-shaped connection (sym.7), welded to the bottom of the hermetically sealed casing, and flows through the connection into the radially positioned ducts along the rear, inner wall of the casing. The air then flows into longitudinal ducts on the upper side walls inside the casing and discharges through holes at the forward panel. The ducts are formed by channel bars (sym. 3) welded to the inner wall of the sealed casing. These channels, in addition, provide rigidity to the

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casing design.

When air temperature in the intake duct is increased because of an increase in the Mach number (M 1.5), that is, when the air temperature used for scavenging the transceiver rises above 50°C, scavenging is automatically discontinued.

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Figure 33. Transceiver scavenging diagram

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Figure 33. Scavenging diagram, radio set transceiver

1. Transceiver
2. Outer wall of hermetically sealed casing
3. Channel bars
4. Inner wall of hermetically sealed casing
7. Pi-shaped connection
8. Hose
9. Cutoff valve
10. Electrically operated valve, EK-69 (140M)
33M. AZS-10 "Cone, throttle interlock"
50M. Filter in the Mach number controller circuit
66M. Mach number controller
116M. TKYe-52PD relay

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When a Mach number M $\geq$ 1.5 is attained, 27 volts is fed from the Mach number controller (sym. 66M) to terminal A of the relay winding (sym. 116M). The relay operates and 27 volts from the aircraft network is supplied to

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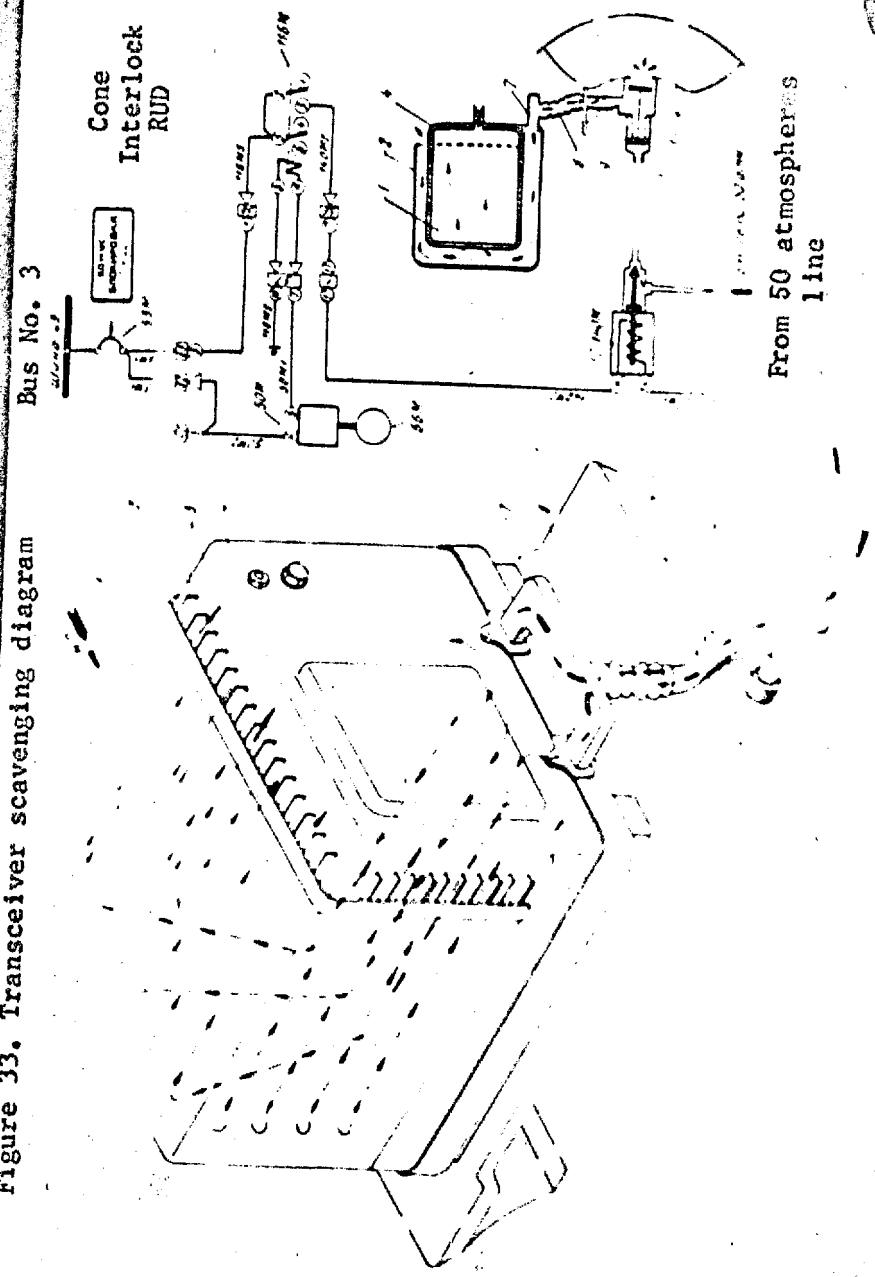

Figure 33. Transceiver scavenging diagram

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terminal 1 of the electrically operated valve (140M) through the normally open contacts 2-3 of the relay (sym. 116M). EK-69 operates and, under air pressure of 50 atmospheres, the piston moves the valve disc, which covers the opening providing air intake from the intake duct.

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5. Controlling operation of the radio

Control of the ultra-short wave radio set for communications has been reduced to a minimum number of operations:

1. Start the set by cutting in the AZS stencilled "Radio" on the forward electrical switchboard of the starboard console. Operational readiness of the set is provided for in not more than 1.5 to 2 minutes after the supply is cut in.

2. Select one of 20 pre-tuned communications channels by setting the "Channel" transfer switch on the P-1 control panel to the position corresponding to the given channel (the number of the channel selected will be set in the window in the control panel cover). The transfer time from channel to channel is 4 seconds.

3. Switch the set from "Receive" to "Transmit" by pushing the button for energizing the transmitter mounted on the handle of the engine control lever (gas sector or throttle). The time to switch from receive to transmit and vice versa takes not more than 0.5 second.

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Additional Operations

1. Adjust the phone volume by turning the "volume" adjustment knob on the P-1 control panel.

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The amplified and automatically regulated sensitivity of the receiver tract which is available in the set permits a reduction in the change in the receiver output voltage connected with the change in field intensity as the aircraft recedes from or approaches another aircraft or ground stations. The amplified and automatically regulated sensitivity of the receiver tract frees the operator from making repeated volume adjustments for the phones when communicating.

2. Cut the noise suppressor in and out by shifting the tumbler switch for the noise suppressor on the P-1 control panel to "Noise Suppressor" or "off" positions.

3. Shift the transmitter power by switching the tumbler switch for power on the P-1 control panel to the "Full Power" or "Reduced" positions.

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4. Connect the automatic radio compass output in series with the output of the radio and connect both to the phones in order to hear both simultaneously by shifting the tumbler switch "Radio Compass" on the P-1 control panel to the "Compass" position.

6. Electrical supply for the radio set

The communications radio set is supplied with 27 volts direct current from the aircraft network and with 115 volts, 400 cycle, single phase alternating current from the PO-750A converter, which converts the aircraft network direct current into the 115 volts, 400 cycle single phase alternating current.

The Communications ultra-short wave radio set takes single phase

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alternating current at 115 volts, 400 cycles, from the network:

(a) when transmitting at rated power, 400 volt amperes;

(b) when transmitting at reduced power, 270 volt amperes;

(c) when receiving, 200 volt amperes.

The weight of the operational radio set complex is 32.7 kilograms.

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7. Installation location and methods of securing blocks

Transceiver (blocks A, B, V) - installed in the upper equipment compartment (directly under the equipment hatch cover) between frames numbers 4 and 5. Shock mounting for the blocks A, B, V is accomplished by the placement of four damped shock mountings (two type AD-7, two type AD-8).

The shock mountings are secured to block "V." Blocks A, B, V are set in a frame secured directly to two subframes with four screws which screw into anchor nuts of two brackets which are fastened to the sheathing of the intake duct.

P-1 control panel (figure 34) - installed in the cockpit on the vertical section of the port console between frames 8 and 9 on a bracket riveted to the sub-canopy panel and frame number 9. The panel is secured to the bracket by two screws for two bosses on one side and by a boss which is threaded into the bracket impingement on the other.

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The push button for cutting in the RSIU radio set to transmit is installed in the cockpit, on the port console, on the throttle.

The combination whip antenna for the RSIU and the ARK-10 is installed on the after fixed section of the canopy, between frames numbers 13 and 14

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and is secured to an insulated panel made of Mark AR-4 press (board) material by four bolts. The panel is secured to the anchor nuts of two diaphragms riveted to the upper fuselage panel by four screws.

In order to prevent breakage of the high frequency feeder for the RSIU and ARK-10 antenna in the event the tail section of the canopy is removed two warning stencils have been mounted. One, at the site of the first fastener for the antenna feeder (frame no. 13) reads: "Feeder length, from antenna to first fastener, must be 320-mm." The other, on the fuselage (between frames nos. 13 and 15, port side), reads: "When removing the tail section of canopy disconnect communications radio set feeder."

AF-1 Filter (separation) for the RSIU and ARK-10 combined whip antenna - installed on the after, fixed section of the canopy, between frames 13 and 14, and secured to the RSIU and ARK-10 combined whip antenna by screws, from underneath. The AF-1 filter is screened in order to eliminate interference, as well as to improve bonding.

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Figure 34. P-1 control panel for the ultra-short wave communications radio set

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The UK-2M series "B" amplifier (figure 35) is installed in the cockpit, on the port console, at frame no. 10 and is secured by 3 ears as follows:

two of the ears are fastened to a runner welded to the horizontal section of the port console framework; the third ear is secured to a bracket which is mounted on the face of frame no. 10.

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The separation transformer is installed in the cockpit, port side, between frames nos. 10 and 11, on a bracket to which it is secured with two bosses. One of the bosses is secured to the bracket channel, the other is fastened to the bracket by a screw.

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Figure 35. UK-2M series "B" amplifier

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III. Blind landing system

1. Medium wave, automatic radio compass, type ARK-10

Purpose

The medium wave, automatic radio compass, type ARK-10 is designed to guide the aircraft by a homing radio station, a broadcasting station, or by a radio beacon and ensures continuous computation of course angle (the angle between the longitudinal axis of the aircraft and the direction to the radio station)and the solution to the following navigational problems:

1. flight to and from the radio station, with visual indication of course angle;

2. automatic determination of radio station bearings from the course indicator;

3. landing by instruments using the OSP blind landing system;

3. determination of distance to the homing radio station by the route integration method;

4. reception of and listening to signals from radio stations transmitting on medium waves in the frequency band 120 to 1340 kilocycles.

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Figure 35. UK-2M series "B" amplifier

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Composition

The medium wave, automatic radio compass, type ARK-10, as installed in the air-

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craft, includes the following:

1. receiver;
2. supply block;
3. control panel;
4. remote wave transfer switch;
5. UGR-4U course indicator (part of the KSI complex);
6. tuning indicator;
7. "Short-Long" transfer switch;
8. UAP-1 transfer switch all-purpose automatic device;
10. "ARK BPRS" indicator light;
11. antenna amplifier;
12. AF-1 filter for the RSIU and ARK-10 combined whip antenna;
13. RSIU and ARK-10 combined (non-directional) whip antenna;
14. directional antenna block;
15. feeder equivalent (5M) in the channel of the directional antenna (two);
16. feeder equivalent (18M) in the RSIU and ARK-10 combined whip antenna channel;

17K - 26K - runs and feeders.

Figure 36 is the schematic of the connections and the location in the aircraft of the blocks which make up the ARK-10 radio compass.

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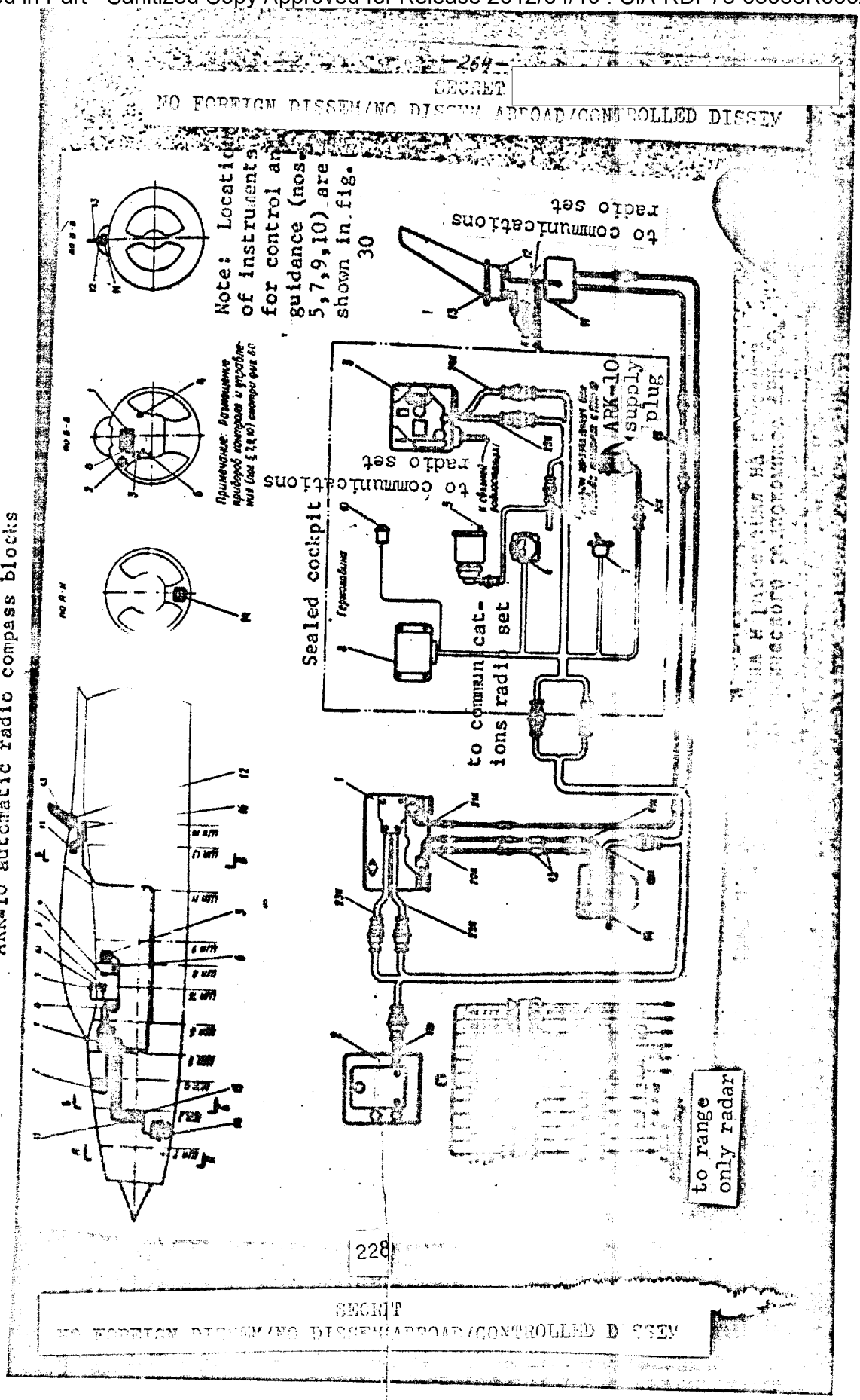

Figure 36. Schematic of connections and location in the aircraft of the ARK-10 automatic radio compass blocks

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Figure 36

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Figure 36. Schematic of connections and location in the aircraft of the automatic radio compass ARK-10 blocks

1. Receiver
2. Supply block
3. Control panel
4. Remote wave transfer switch
5. UGR-4U course indicator (part of the KSI complex)
6. Tuning indicator
7. "Short-Long" transfer switch
8. UAP-1 transfer switch all-purpose automatic device
10. "ARK BPRS" indicator light
11. Antenna amplifier
12. AF-1 filter for the RSIU and ARK-10 combined whip antenna
13. RSIU and ARK-10 combined (non-directional) whip antenna
14. Directional antenna block
15. Feeder equivalent (5M) in the directional antenna channel
16. Feeder equivalent (18M) in the RSIU and ARK-10 combined whip antenna channel

17K - 26K - runs and feeders

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Operating principles

The ARK-10 automatic radio compass operates on the principle of converting a signal from a radio station, picked up by two antennae (a direc-

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tional loop antenna for the ARK-10 and a non-directional RSIU and ARK-10 combined whip antenna), and using it for automatic rotation of the loop antenna to the position of zero reception (the direction of the axis of the loop antenna coincides with the direction to the radio station) and to track this position for any aircraft course changes.

The automatic rotation of the loop antenna to the position of zero reception (in the event of its deviation from this position after tuning to the radio station being received) and automatic tracking, by the loop antenna, of the zero reception position for any aircraft course changes, is accomplished by the use of an automatic servo system (circuit for automatic rotation of the loop antenna) which is part of the radio compass. It consists of a control circuit and an electric motor for rotating the loop. The servo is controlled by low frequency voltage from the output of the radio compass superheterodyne receiver.

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The phase of the control voltage is determined by the direction of the deviation, while the amplitude is determined by the magnitude of the deviation of the loop antenna from the direction to the radio station.

The selsyn system contained in the radio compass transmits the angular displacements of the loop (automatically established by the plane of the turns in the loop perpendicular to the direction to the radio station) to the pointed indicator for the radio compass, the UGR-4U indicator of the KSI compass.

The feeder for the directional antenna and for the ARK-10 receiver, as well as the antenna amplifier cable, is covered with braided shielding to

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eliminate interference in the ARK-10 radio compass resulting from other stations.

Operating Modes

The medium wave, automatic radio compass, type ARK-10, is designed for three modes of operation:

1. Automatic direction finding - "Compass" - in which a signal voltage is

taken from the ARK-10 directional loop antenna, as well as from the non-directional, RSIU and ARK-10 combined whip antenna. In this mode, when the radio compass is tuned to the frequency of the radio station sending the beam, the course angle to this radio station is automatically set on the UGR-4U course indicator of the KSI complex.

2. Acoustic direction finding - "Loop" - in which a signal voltage is taken only from the directional loop antenna (the non-directional antenna is disconnected). In this mode, and when tuned to the frequency of the radio station sending the beam, the radio compass enables the operator, by rotating the loop antenna (using the transfer switch for manual rotation marked "L-P Loop") and listening, at the same time, to the station signal, or, at the same time, observing the signal strength on the tuning indicator, to determine the loop direction corresponding to minimum (or zero) reception. The UGR-4U course indicator will show either the course angle to the radio station, or the angle which differs from it by 180°.

3. "antenna" - in which a signal voltage is taken from the RSIU and ARK-10 whip antenna (the compass section is disconnected).

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In this mode the radio compass functions as an ordinary medium wave communications receiver and is considered to have a sufficiently high degree of sensitivity and interference resistance.

In the "Loop" and "Antenna" modes the type ARK-10 radio compass permits listening to modulated, as well as to unmodulated, signals.

Controlling radio compass operation

Remote electrical control of the operation of the automatic radio compass is carried out from the control panel installed on the vertical section of the starboard console in the cockpit between frames nos. 8 and 9, and includes the following operations:

1. cutting in the radio compass by moving the transfer switch from the "Off" position to the type of operation, that is, to one of three positions - "Compass," "Antenna," or "Loop." First, however, the AZS marked "ARK" on the after electrical switchboard of the starboard console in the cockpit must be cut in.

2. remote tuning of the receiver to the selected frequency:

or tuning to any frequency in the operating band, by means of setting the knob of the band transfer switch and the "Coarse tuning" knob and "Fine tuning" (first having pressed the push button marked with the letter "P") to the corresponding

position;

or tuning to a fixed frequency, by means of pressing the push botton corresponding to the previously assigned frequency. Frequencies for the

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closest radio stations are fixed by the push buttons with the even numbers (2, 4, 6, 8), while the frequencies for the distant radio stations are fixed by the push buttons with the odd numbers (1, 3, 7, 9). The closest station, and the most distant corresponding to it, have the proximate numbers.

The even numbered push buttons on the control panel, that is, all the close-by radio stations, have been set on the remote wave transfer switch which is installed on the vertical section of the port console in the cockpit.

When turning to a landing the shift from the distant homing radio station, set by having pressed the push botton on the control panel, to the close homing radio station, set by the position of the remote wave transfer switch, is done automatically by the all-purpose, UAP-1 transfer switch automatic device. The ARK BPRS indicator light on the instrument panel lights up.

Manual tuning of the radio compass by use of the "Short-Long" transfer switch in the aircraft is retained. (When the UAP-1 transfer switch is operated the "SHort-Long" transfer switch must be set to the "Long" position).

3. Switching the radio compass band pass by switching the tumbler switch with the inscription "Broad - Narrow" to the corresponding position.

4. Switching the "Telephone" and "Telegraph" operating modes by switching the tumbler switch with the inscription "Tlf - Tlg" (Telephone-Telegraph) to the corresponding position.

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5. Adjusting receiver gain in "Antenna" and "Loop" modes and adjusting signal volume in the phones in the "Compass" mode by rotating the volume control knob with the inscription "Volume Control."

6. Remote rotation of the directional antenna to both sides, used when operating in the "Loop" mode, by using the tumbler switch with the inscription "Loop L-P." Loop antenna rotation will continue as long as the tumbler is held down.

Electrical Supply for the Radio Compass

The electrical supply for the type ARK-10 radio compass is obtained from the aircraft's network, 27 volts direct current, as well as from the PO-750A converter, which converts the network direct current into 115 volts, 400 cycle alternating current.

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Power requirements from the direct current network:

(1) with the heating circuit, the drum-type transfer switch motor, and the automatic tuning equipment operating, the requirement is almost 450 watts;

(2) with the heating circuit cut in, but with the control mechanisms cut out, the requirement is about 250 watts.

The demand on the 115 volts, 400 cycles, alternating current network is about 150 volt-amperes.

Installation Location and Method of Securing Blocks

The ARK-10 receiver is installed in the upper equipment compartment, between frames nos. 5 and 6 (under blocks nos. 4, 5, 6 and 8 of the ASP-5ND sight; above the SRO transceiver), on a shock-mounted frame, with the

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front panel facing to starboard. The frame is secured to a bracket which is rigidly connected to frame no. 5 and the inlet duct sheathing. On this side catches are used. On the other side the frame is set in a recess for two special bolts which are, at the same time, used to secure the armor plate to frame no. 6.

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The supply block is installed in the upper equipment compartment, between frames nos. 3 and 4 (closer to frame no. 4), to starboard, directly under the equipment hatch cover and is, on the one side, secured by two screws to the bracket anchor bolts. The brackets are secured to the upper longeron. On the other side the block is secured by toggle bolts set in a clip secured to a stringer.

The ARK-1- control panel (figure 37) is installed on the middle, vertical panel of the starboard console in the cockpit, between frames nos. 8 and 9 and is secured to the console frame by lug bolts on one side and by the installation of two other lugs under a bracket welded to the frame on the other side.

The remote wave transfer switch (figure 38) is installed in the cockpit, on the vertical section of the port console, between frames nos. 8 and 9.

The UGR-4U course indicator is installed in the cockpit, on the port, movable, section of the instrument panel, and is secured to the instrument panel by four bolts which screw into a flange.

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Figure 37. Photograph captioned "Control panel for automatic radio compass, ARK-10"

Figure 38. Photograph captioned "Remote wave transfer switch for automatic radio compass, ARK-10"

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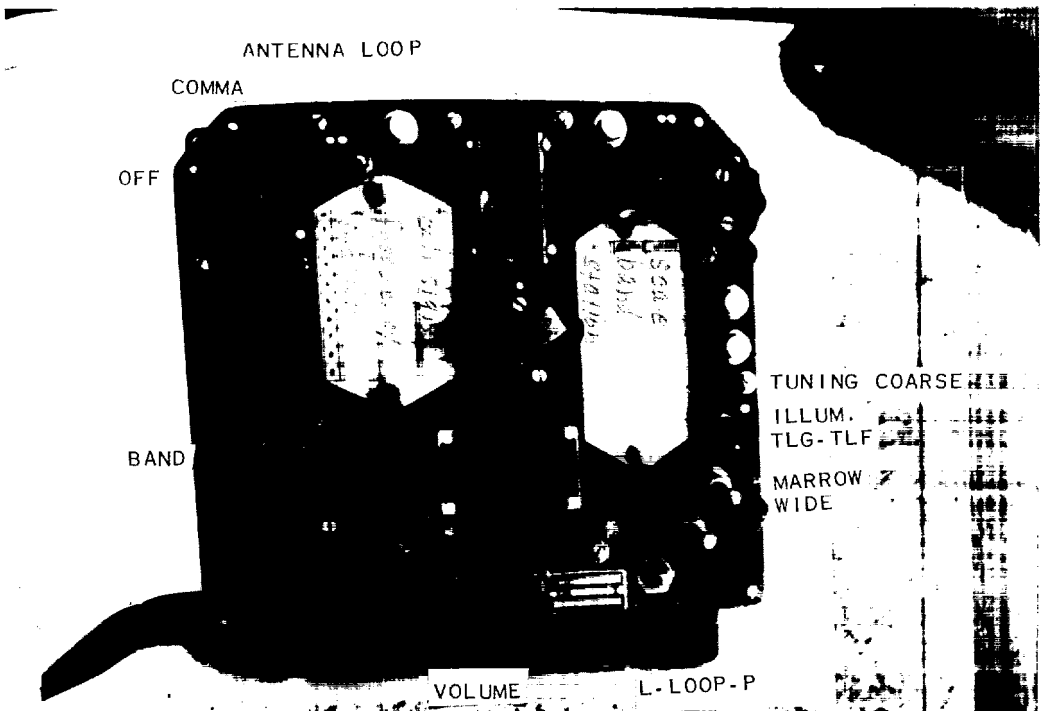

Рис. 37 Пульт управления автоматического радиокомпаса АРК-10.

Figure 37. Control panel for automatic radio compass ARK-10

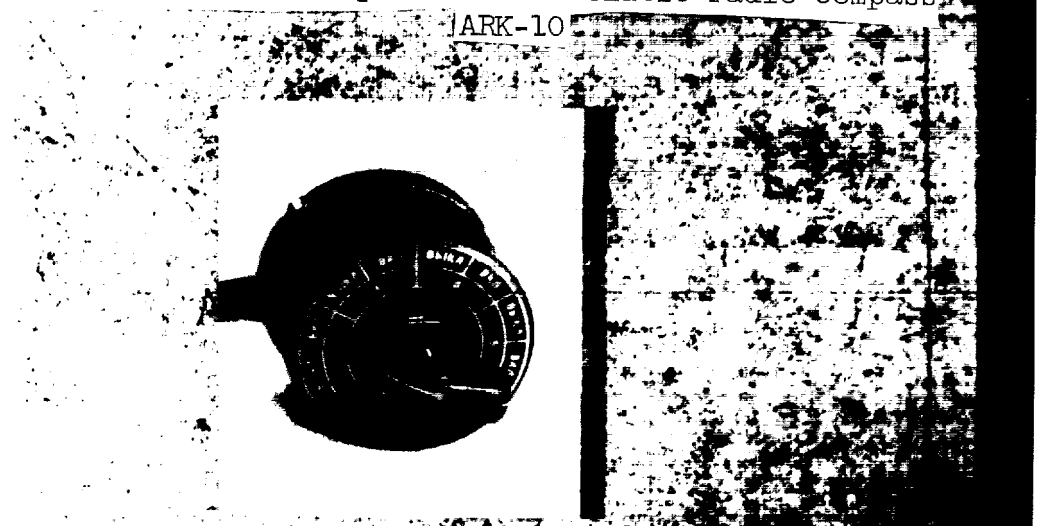

Рис. 38. Дистанционный переключатель автоматического радиокомпаса

Figure 38. Remote wave transfer switch for automatic radio compass ARK-10

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Tuning indicator (ammeter) is installed in the cockpit on the horizontal section of the starboard console (figure 39).

The "short-long" transfer switch is installed in the cockpit, on the port, movable panel of the control panel.

The UAP-1 all-purpose switching device is installed in the cockpit, behind the instrument panel, to the starboard side.

The antenna amplifier is installed in the vicinity of frame no. 13, on the after, fixed section of the canopy and is secured by four screws which pass through the base and which are held by anchor bolts to the bracket secured to the fixed section of the canopy.

The antenna control block is installed in the nose section of the fuselage, between frames nos. 2 and 3, underneath, in a special hatch, along the aircraft's axis of symmetry and is secured by screws to anchor bolts on the hatch frame.

Attention! In order to do away with the possibility of breaking the feeder to the combination antenna in the course of removing the tail section of the canopy, the feeder is installed so as to have a length of 320 millimeters between the antenna and the first point where it is secured to frame no. 13.

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Figure 39. Photograph captioned "Tuning indicator (ammeter)"

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2. Low altitude radio altimeter, type RV-UM

Purpose

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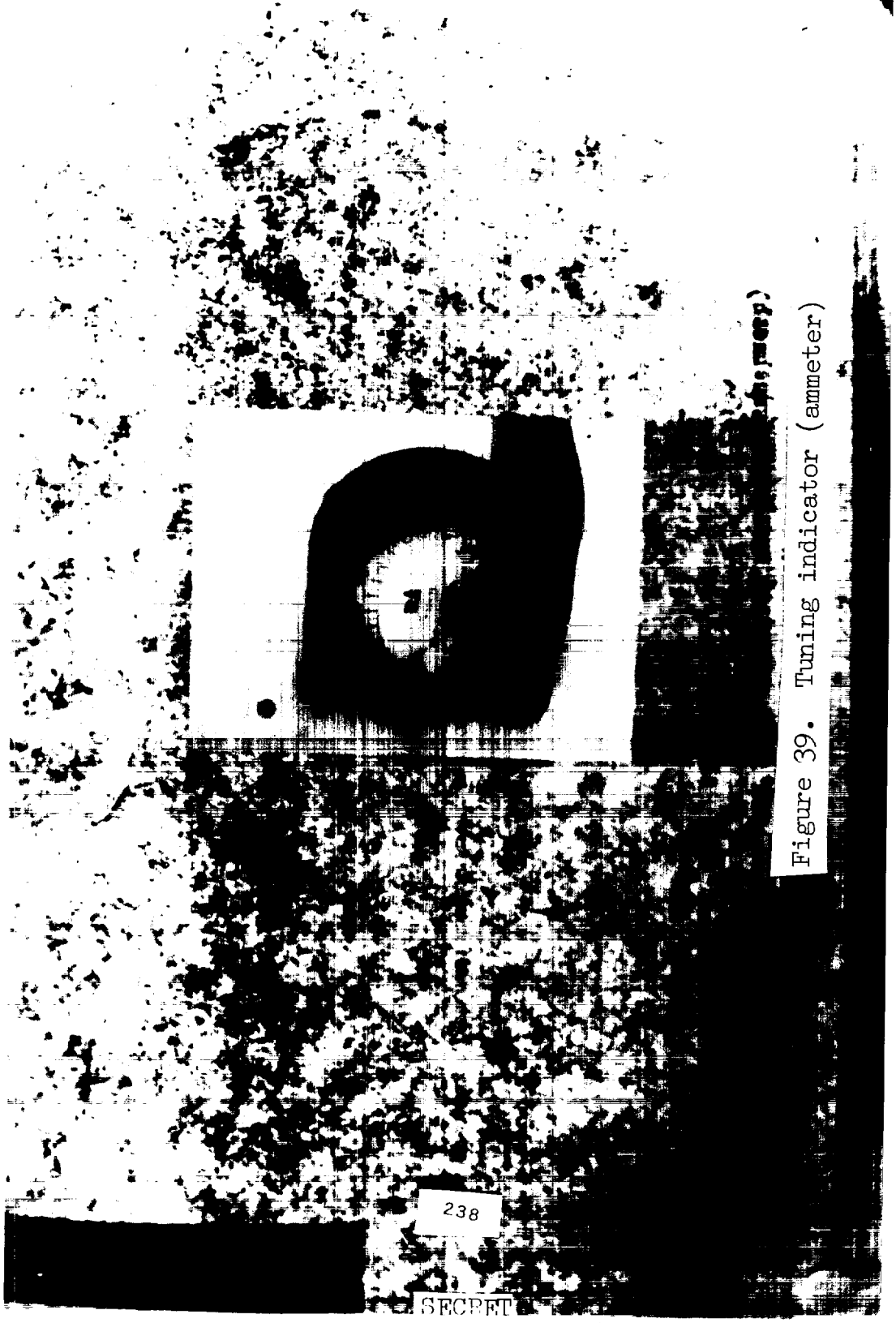

Figure 39. Tuning indicator (ammeter)

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The type RV-UM low altitude radio altimeter is designed to determine the true flight altitude of the aircraft above the ground surface and to ensure signalling of the dangerous altitude previously set by the pilot.

Composition

The type RV-UM low altitude radio altimeter, as installed in the aircraft, includes:

1. the transceiver - block PP-U;
2. transmitting antenna;
3. receiving antenna;
4. UV-57 altitude indicator
5. Indicator pilot light (red)
6. PSV-U dangerous altitude transfer switch
7. VChF-3 filter

7K-19K - runs and feeders

The schematic of connections and location of the RV-UM radio altimeter blocks in the aircraft is shown in figure 40.

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Figure 40. Schematic of connection and location of RV-UM radio altimeter blocks in the aircraft

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Figure 40. Schematic of connections and location of RV-UM radio altimeter in the aircraft

1. Transceiver - PP-U block
2. Transmitting antenna
3. Receiving antenna
4. UV-57 altitude indicator

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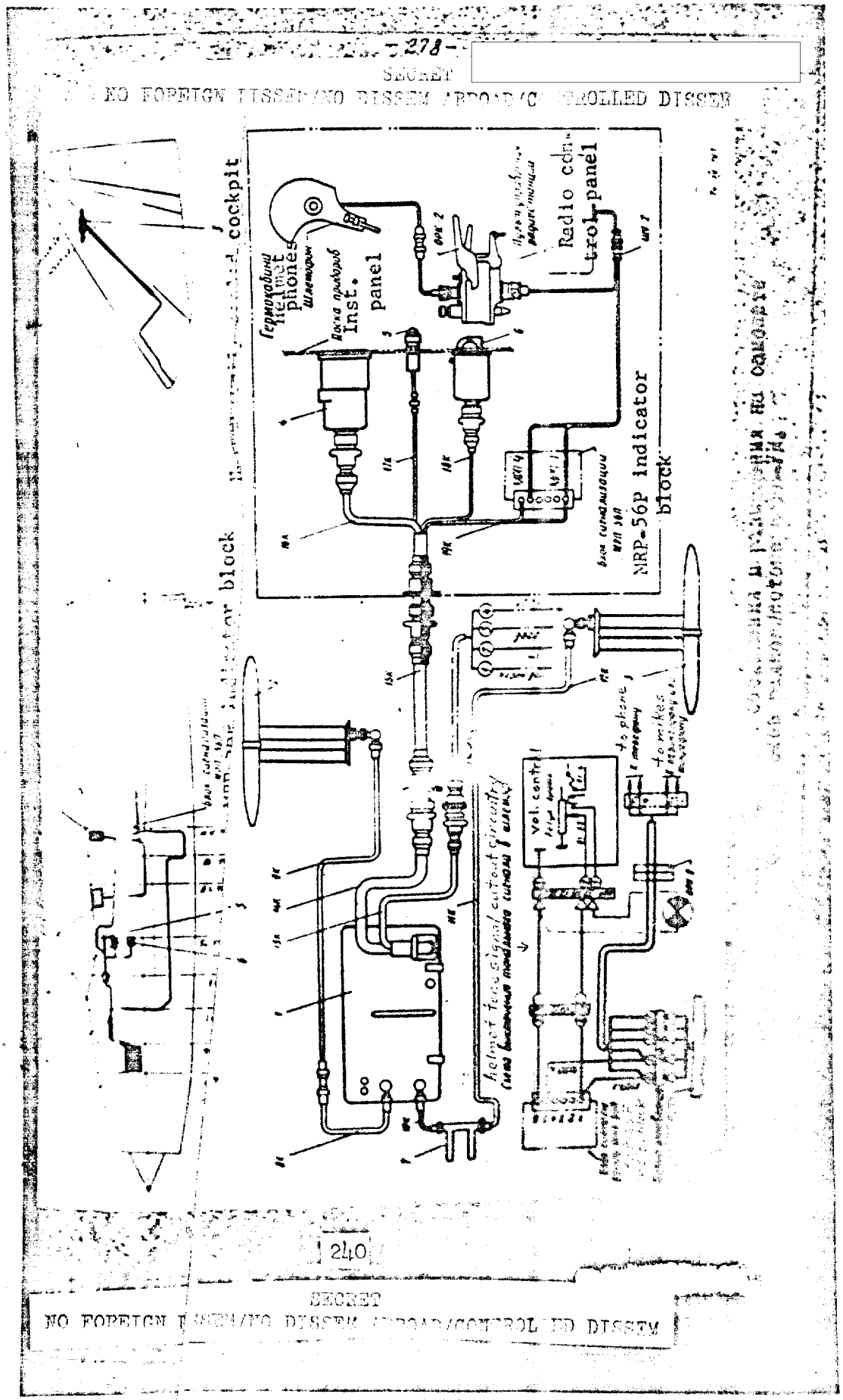

Figure 40. Schematic of connections and location of RV-UM radio altimeter blocks in the aircraft

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5. Indicator pilot light

6. PSV-U dangerous altitude transfer switch

7. VChF-3 fliter

7K-19K - Runs and feeders

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Operating principle and brief technical data

The type RV-UM radio altimeter operates on the basis of the phenomenon that radio waves are reflected from the earth's surface. In order to determine the altitude at which the aircraft is flying the frequency modulation of a radiated signal is used (as time passes the frequency of the radiated signal changes in accordance with a fixed law; the amplitude remains constant). The frequency used to modulate the signal radiated by the transmitting antenna of the radio altimeter is 70 cps ± 10 cps. The width of the modulation band is 17 megacycles. The altitude measured is from 0 to 600 meters with an accuracy of ± 5 meters to within ± 8 percent.

The signal radiated by the transmitting antenna of the radio altimeter reaches the ground and is reflected by it, to be picked up by the radio altimeter's receiving antenna and fed to the receiver input. A special feeder inside the radio altimeter transceiver supplies a direct signal, directly from the transmitter to this same input. The path of the return signal (it will depend upon the flight altitude of the aircraft above the ground) lags behind the path of the direct signal, so that the reflected signal is fed to the receiver input later than the direct signal. Because of the use of frequency modulation, the frequency of the reflected signal will be different from that of the direct signal by a value which is directly

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proportional to the altitude of the aircraft. As a result of the structure of the direct and reflected signals, a voltage

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occurs in the receiver which is the beat frequency between these two signals and is proportional to the altitude above the ground.

Radio altimeter operation

Radio altimeter operation reduces to three basic times:

1. radiation of high frequency oscillations from the SVCh (super-high frequency) generator, frequency modulated, from the transmitting antenna;

2. reception of signals reflected from the ground by the radio altimeter's receiving antenna;

3. measurement of the time between the moment of radiation of the frequency modulated signal and the moment it is received, by measuring the beat frequency of the direct and reflected signals which depends upon the aircraft's altitude. (The beat frequency is directly proportional to the altitude, the modulation frequency, the modulation band and is inversely proportional to the radio wave propagation velocity). The beat frequency voltage is converted into a direct current in the transceiver of the RV-UM radio altimeter proportional to the beat frequency. The current obtained passes through the UV-57 altitude indicator and delfects its needle. Since the value

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of the current is proportional to the beat frequency, and the beat frequency is proportional to the aircraft altitude, the scale is graduated

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directly into altitude in meters.

In order to avoid false indications on the UV-57 altitude indicator at altitudes in excess of 600 meters, the RV-UM radio altimeter transceiver has an interlock circuit which moves the indicator needle into the right stop.

The transceiver also has a signal circuit for dangerous altitude which provides a light and sound indication for the pilot when the aircraft descends to one of the previously fixed, and set by the pilot, (dangerous) altitudes. The signal of dangerous altitude sounds (a 400 cycle signal which is interrupted every 2 to 3 seconds) in the pilot's helmet, and he is, at the same time, warned visually (a red pilot light on the port, movable panel on the instrument panel in the cockpit, lights up). Signals for dangerous altitude occur at the following altitudes: 50 meters, 100 meters, 150 meters, 200 meters, 250 meters, 300 meters, 400 meters, in accordance with the position of the dangerous altitude transfer switch.

When the radio altimeter is cut in on the ground the sound signal functions and the red pilot light lights up and it will burn until such time as the aircraft climbs to an altitude which is higher than the setting on the dangerous altitude transfer switch.

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Radio altimeter electrical supply

The supply for the type RV-UM low altitude radio altimeter comes from the aircraft direct current network through the PO-750A converter, which converst the network direct current into single-phase, alternating current

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at 115 volts, 400 cycles. The 115 volts, 400 cycles voltage is fed to the PP-U transceiver and delivered to the supply circuit installed in it and which consists of the anode-filament transformer, a rectifier with a two-section pi-section filter made up of chokes and condensers; it is stabilized.

The type RV-UM low altitude radio altimeter is cut in by closing the AZS bearing the nameplate "Marker, RV-U" on the forward electrical switchboard on the starboard panel in the cockpit.

Installation Location and Method of Securing Blocks

The transceiver of the RV-UM radio altimeter is installed in the upper equipment compartment, between frames nos. 3 and 4 on a horizontal stiffener below the nosewheel on the frame and secured by two screws and anchor bolts to a bracket. Four shock mounts are secured to the frame which carries the transceiver block panel.

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The transceiver is secured to the shock-mounted panel by lugs which are inserted in special openings in the panel on one side and by catches which the clips fit into and tightened to the panel by screws on the other side. The transceiver is installed with its front panel facing frame no. 4. Access to the block is through a special door.

The receiving antenna for the RV-U radio altimeter is installed on the starboard wing, underneath, between the tips of ribs nos. 23 and 24. The antenna is secured by four screws which pass through the flange and are held by four anchor nuts on the lower wing sheathing. The receiving antenna is positioned along the direction of flight (with an accuracy of ±2°).

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The transmitting antenna for the RV-U radio altimeter is installed on the port wing, underneath, between the tips of ribs numbers 23 and 24. The antenna is secured by four screws which pass through the flange and are held by anchor nuts on the lower wing sheathing. The transmitting antenna is positioned along the direction of flight (with an accuracy of ±2°).

The UV-57 (figure 41) altitude indicator is installed in the cockpit on the port, movable panel on the instrument panel and fastened to it by four screws which pass through a flange.

The PSV-U dangerous altitude transfer switch (figure 42) is installed in the cockpit on a side panel of the instrument panel and secured to it by four screws

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which pass through a flange.

The dangerous altitude indicator light is installed in the cockpit on the port, movable panel of the instrument panel.

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Figure 41. UV-57 altitude indicator of the RV-UM radio altimeter

Figure 42. PSV-U dangerous altitude transfer switch of the RV-UM radio altimeter

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3. Radio receiver marker installation, type MRP-56P

Purpose

The type MRP-56P radio receiver marker device is designed to indicate the passage of the aircraft over points located at fixed distances from the

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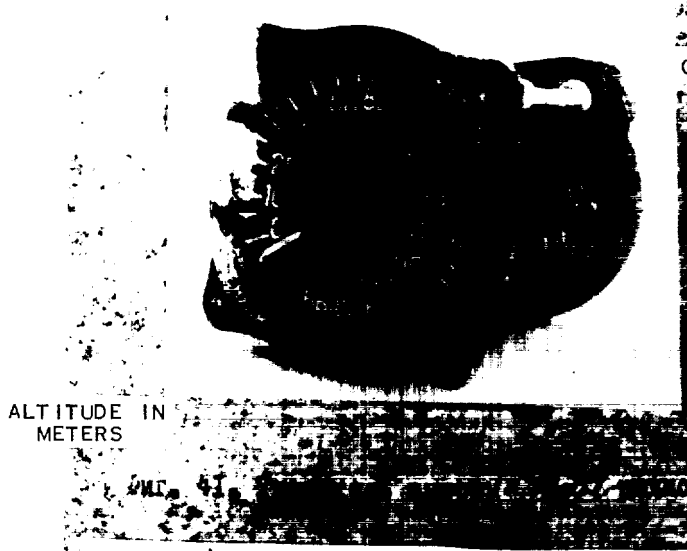

Figure 41. UV-57 altitude indicator of the RV-UM radio altimeter

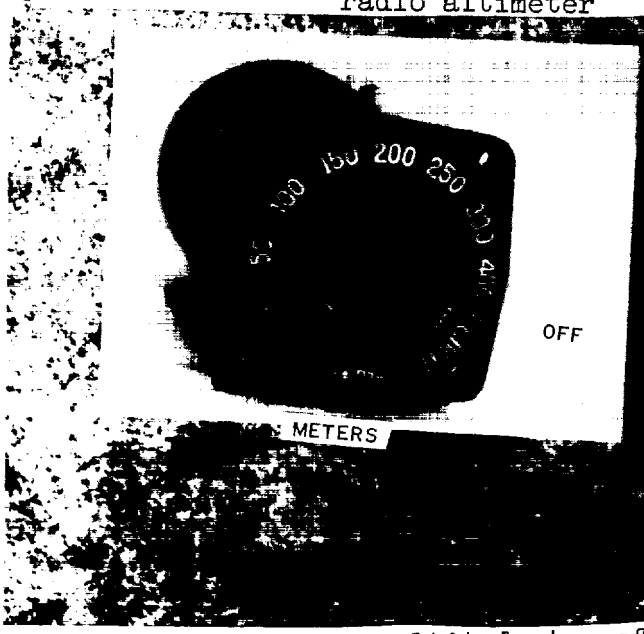

Figure 42. PSV-U dangerous altitude transfer switch of the RV-UM radio altimeter

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landing strip by receiving radio beacon marker signals.

Composition

The following units, which make up the MRP-56P radio receiver marker installation, are installed in the aircraft:

1. the receiver;
2. an antenna inside the fuselage;
3. an indicator block;
4. a "Marker" pilot light;
5. the runs and feeders.

Figure 43 is a schematic of the connections and the location in the aircraft of the blocks which make up the MRP-56P radio receiver marker installation.

Operating principle and brief technical data

The type MRP-56P radio receiver marker installation is part of the system for

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Figure 43. Schematic of connections and location of type MRP-56P radio receiver marker installation in the aircraft

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Figure 43. Schematic of connections and location of type MRP-56P radio receiver marker installation in the aircraft

1. Receiver
2. Antenna inside fuselage
3. Indicator block
4. "Marker" pilot light

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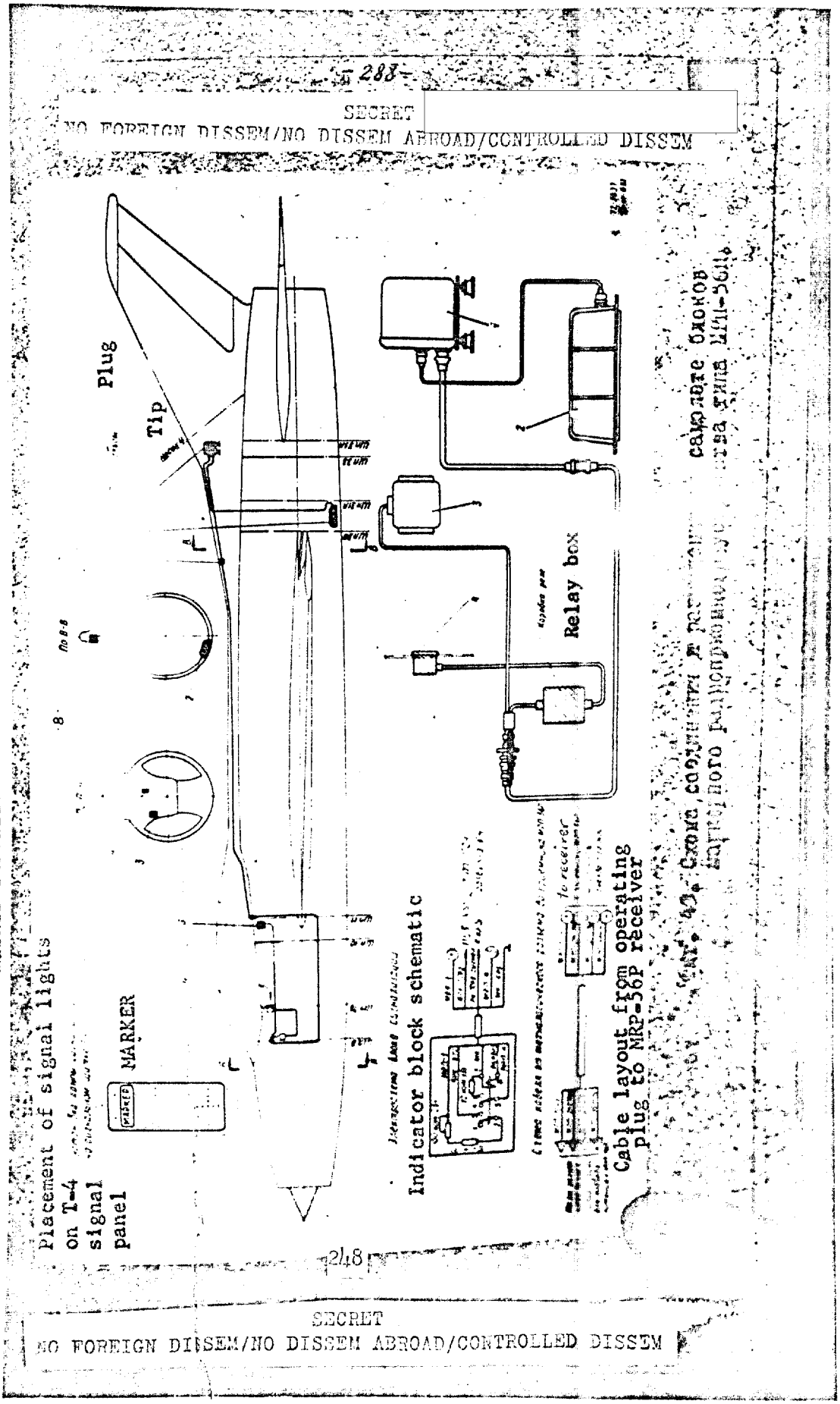

Figure 43. Schematic of connections and location of type MRP-56P radio receiver marker installation in the aircraft

Placement of signal lights on T-4 signal panel

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simplifying the process of landing the aircraft blindly, on instruments. The principle of operation involves the reception of pulses radiated from a marker radio beacon and converting them into light and audible signals of the same duration.

The type MRP-56P radio receiver marker installation operates on a frequency of 65 megacycles. The modulation frequency has an amplitude of 3,000 cycles, while the percentage modulation is 30%.

The supply for the filament circuits of the tubes in the radio receiver is 27 volts from the aircraft on-board network. The anode circuit supply for the radio receiver comes from the receiver of the type RV-UM low altitude radio altimeter and is 220 volts direct current. 115 volts, 400 cycles, alternating current, and 27 volts direct current, are used for the signal circuits.

Purpose, operation, location, and methods used to secure the blocks in the aircraft

The antenna inside the fuselage, used with the MRP-56P radio receiver marker installation, from an electrical point of view, is an unsymmetrical, very short, dipole located inside a metallic cavity and tuned to resonance using loading condensers.

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On the forward side the cavity is covered by an organic glass lid. The antenna is installed in the tail section of the fuselage, between frames nos. 30 and 31A, underneath, on the starboard side, next to the drag-chute compartment, in a special hatch. The antenna is secured to the hatch frame by catches. The hatch cover is installed flush with the skin of the fusleage.

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The receiver in the type MRP-56P installation is designed to amplify a stage of uhf voltage taken from a section of the dipole of the antenna inside the fuselage and deliver it to the receiver. A three-stage, low frequency amplifier is used to rectify the voltage and deliver it to the low frequency amplifier input, the circuit of which contains the winding of relay RE-53-V. At the same time, its contacts close the 27 volt, direct current, circuit which serves to indicate passage of the aircraft over the marker radio beacon.

The receiver is installed in the tail fin fairing, between frames nos. 33 and 33A, on four shock mounts which are secured to the panel.

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The indicator block in the installation is designed to provide an audible signal (at a frequency of 400 cycles) in the helmet phones for the pilot when the aircraft passes over the marker radio beacon.

When a signal is present at the receiver input, and relay RE-53-V operates as a result of this signal, 27 volts is fed to terminal 2 of the indicator block.

This voltage is supplied to terminal A of relay winding in the indicator block. The relay functions. Contacts 3-2 and 6-5 in the relay, normally open, close, and, at the same time, close the 115 volts, 400 cycles, single phase alternating current circuit as well.

An audible signal is fed to the pilot's helmet phones.

The indicator block is installed in the cockpit, on the starboard console, at frame no. 11.

The pilot light, steiled "Marker," is installed in the cockpit, on

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the T-4 signal panel which is secured to the instrument panel by two screws which pass through toggles.

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Figure 44. MRP-56P receiver

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Figure 45. MRP-56P antenna

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IV. Airborne responder in the identification radar system, SRO-1

Purpose

The SRO-1 airborne responder in the identification radar system is designed to identify the aircraft with elements of its own forces by sending coded responses, in the form of signals, upon interrogation by air, ground or seaborne elements.

Composition

The SRO-1 system, as installed in the aircraft, includes the following:

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1. antenna
2. transceiver
3. code panel
4. inertial contactor
5. exploder circuit control panel
6. exploder push button
7. remote transfer switch for "distress" signal
8. F14A filter
9. runs and feeders

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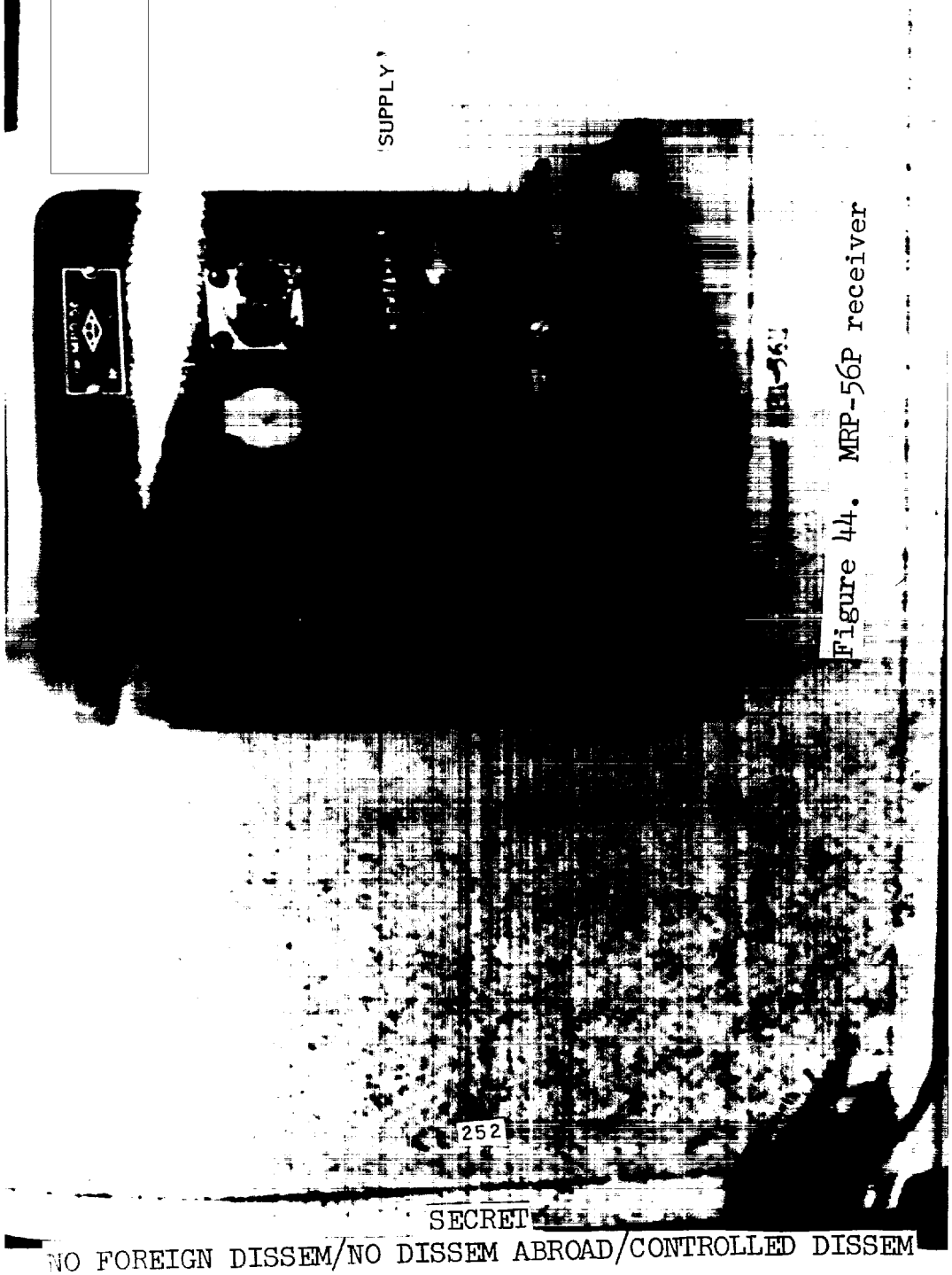

Figure 44. MRP-56P receiver

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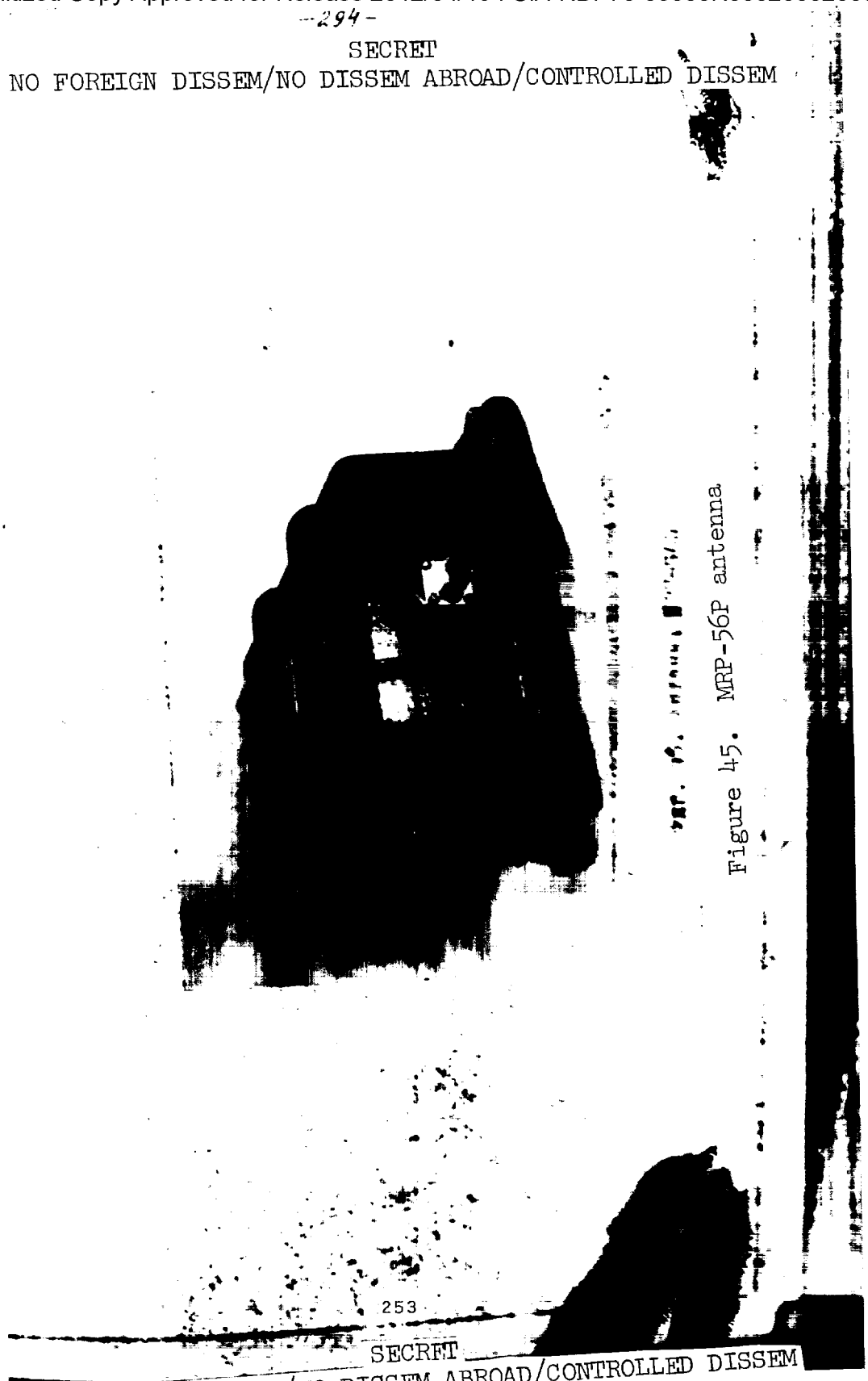

Figure 45. MRP-56P antenna

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The schematic showing the manner in which the airborne responder in the SRO-1 radar recognition system is connected is given in figure 46. [page 305]

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Principle of operation

The airborne responder in the SRO-1 radar recognition system is connected with a series of interrogators which can operate on different frequencies. In order to provide the possibility for responding to any interrogator, there is a provision in the SRO-1 responder for a smooth change with respect to time in the frequency to which tuned, ensuring coverage in the frequency range between 160 and 170 megacycles. The tuning process takes place automatically.

The smooth change which occurs in the frequency tuning is attained by changing the inductance in the high frequency circuit by varying (with a special mechanism) a short-circuited loop inside the leg. The time to change the frequency, within the limits indicated above, from the minimum to the maximum value, and return, is the time for one cycle of variation, and is equal to 0.64 second. The variation cycle consists of the forward and back movement of the loop. Reception of the interrogating and the transmission of the answering signals occurs only during the forward

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movement of the loop. During the return movement the responder is blocked. (The high frequency circuit is common to the receiving and transmitting stage in the responder. Consequently, reception of the interrogating and transmission of the responding signals takes place, for all practical purposes,

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on one and the same frequency of circuit tuning).

The coding of the response signals is in accordance with the Morse alphabet. The "dot" corresponds to a pulse of short duration, while the "dash" corresponds to one of long duration (2.5 to 3 times the width of the short, or narrow, pulse).

Each code in the given coding system is a letter in the Morse system, and consists of a maximum of four signs (pulses). In order to keep the letters from merging into each other while reading the code, the letters are separated by pauses. Thus, the code consists of a collection of pulses and pauses within 5 tuning cycles (so that the fifth cycle is always used for the pause) which requires 3.2 seconds for its transmission.

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The airborne responder in the SRO-1 radar recognition system has four, one-letter codes. In addition, a special distress signal is incorporated in the SRO-1 responder - a broad pulse, the length of which is considerably longer than the length of the ordinary pulse in any of the codes. The distress signal is transmitted on that cycle of the tuning which is used as a pause, so that the transmission of the code which is set up is unchanged.

The responder contains a detonator for blowing up the transceiver installation. The detonator is set off either by the pilot himself by means of the exploder button in the cockpit on the horizontal section of the starboard console, or by automatic operation of the inertia contact, which functions in the

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event the aircraft falls.

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Purpose, brief description of characteristics, and the methods used to secure the SRO-1 responder blocks in the aircraft

The SRO-1 responder transceiver is made up of the transceiver proper and supply block which, from the design standpoint, is made in two chassis. Both blocks are fastened with screws and covered with individual covers.

The transceiver is installed in the upper equipment compartment, between frames nos. 5 and 6.

The antenna, common to the receiving and transmitting sections of the responder, is designed to receive high frequency interrogation pulses and to radiate answering, coded pulses from the SRO-1's radar responder.

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The antenna, with its tuning cells (segments of a long line, made in the form of a cylinder, with a movable plunger in it, serves as the tuning cell) is a stub dipole with a conveniently faired section 260 millimeters high.

The antenna is installed in the nose section of the fuselage, between frames nos. 21 and 22, on top, along the axis of symmetry of the aircraft.

The code panel is designed to replace change codes, control and monitor the operation of the SRO-1 responder.

The code panel is installed in the cockpit, on the vertical section of the starboard console.

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The inertial contactor is designed to automatically close the detonator circuit in case of emergency.

The intertial contactor is installed in the upper equipment compartment,

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between frames nos. 4 and 5, on the port side.

The exploder circuit control panel is installed in the upper equipment compartment, between frames nos. 5 and 6, on the port side.

The exploder push button is designed to deliver a voltage from the on-board network to the detonator which, if exploded, will destroy the transceiver installation.

The exploder push button and the "distress" signal transfer switch are installed in the cockpit, on the horizontal section of the starboard console.

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The F14A filter is installed in the upper equipment compartment, between frames nos. 4 and 5, close to the starboard side.

The remote "distress" signal transfer switch is installed in the cockpit, on the horizontal section of the starboard console.

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Figure 46. Schematic of block connections. Responder in the SRO-1 radar identification system.

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Figure 46. Schematic of block connection. Responder in the SRO-1 radar identification system.

1. antenna
2. transceiver
3. code panel
4. inertial contactor
5. exploder control circuit panel
6. exploder push button

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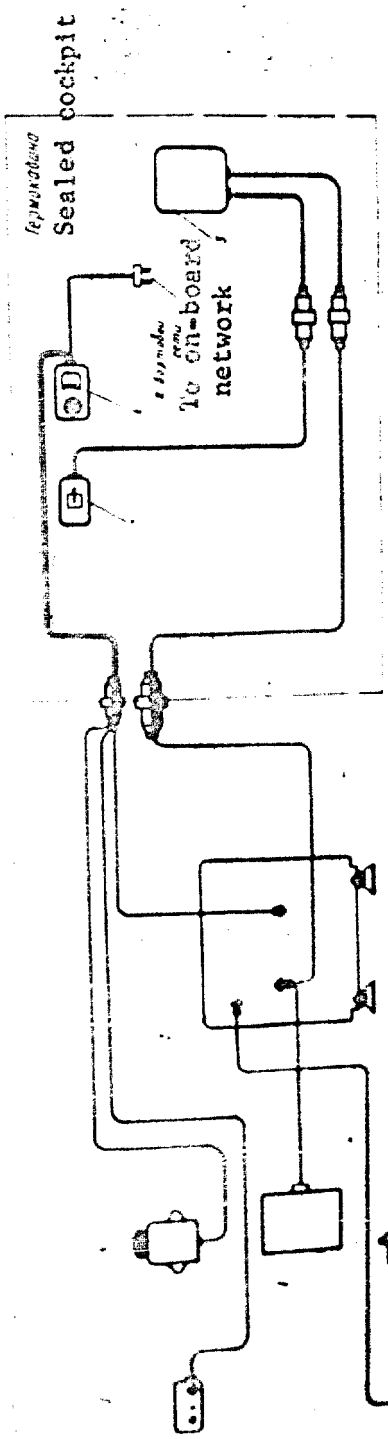

Figure 46. Schematic of block connections. Responder in the SRO-1 radar identification system.

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7. Remote "distress" signal transfer switch

8. F14A filter

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Figure 47. The code panel

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Figure 48. Exploder push button

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V. Airborne range-only radar SRD-5MK

1. Purpose

The airborne range only radar is designed to determine the instant of effective launch of "air-air" homing missiles, as well as for operating with the gunnery sight, and ensures, in the first instance:

(1) automatic, and continuous, determination of true range to the target and transmission of this true range value to the UD-1 range indicator which is installed on a special bracket fastened to the sight range indicator;

(2) automatic comparison of true range with permissible range for launching the K-13 air-to-air homing missiles and delivery of permissible launch signal - a green pilot light for "permissible range" lights up. It is installed on a special bracket;

(3) indication of reaching the range at which the attach is to be broken off (turn away), eliminating the possibility of the pilot being hit by fragments of his own missiles - a red pilot light "withdraw from attach" lights up. It is installed on a special bracket;

in the second instance it ensures:

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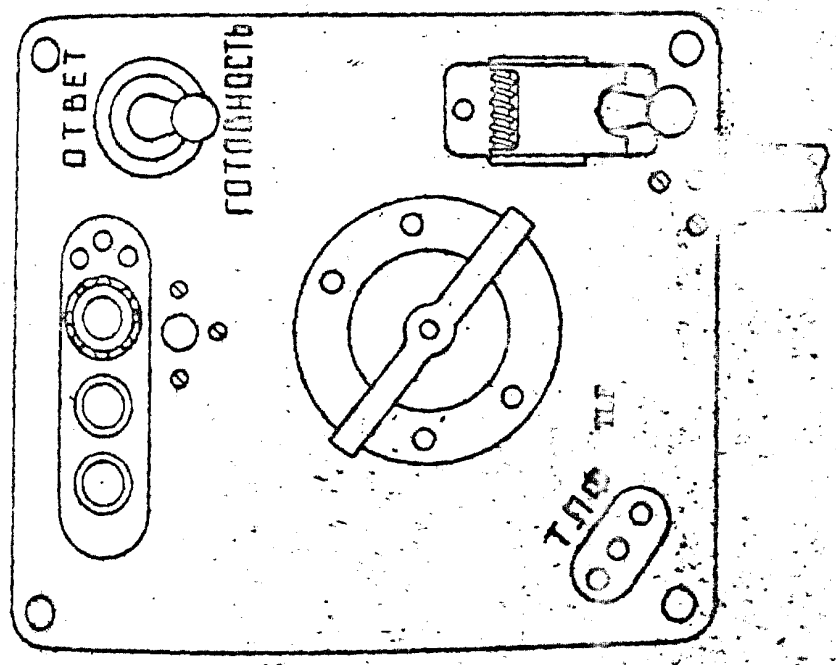

Figure 47. Code panel

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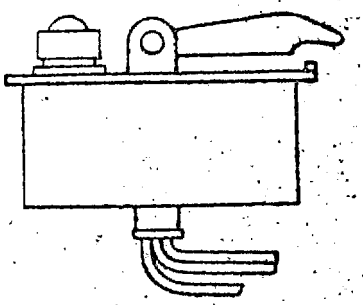

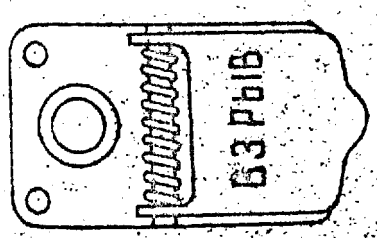

Figure 48. Exploder push button

Exploder

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continuous input to the computer for the gunnery sight of voltages proportional to the range and relative speed of the target.

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2. Composition

The following components are installed as part of the range-only radar system (see figure 49):

1. combination antenna - block K-1 - and waveguide tract;
2. transceiver - block RB6-2M;
3. receiver block - block RB6-3;
4. supply block - block RB6-4;
5. speed block - block RB6-5;
6. monitoring and control panel - block K-6;
7. comparator block - block K-8;
8. permissible range computer VRD-2A;
9. range indicator UD-1;
10. air speed transmitter DVS-5;
11. temperature receiver P-5;
12. "permissible range' indicator light;
13. "withdraw from attach" indicator light;
14. "RS, Cannon-SS" mode switch
15. push button for dropping target;
16. control plug;

16K - 27K. runs and feeders.

The schematic for the connections and the location in the aircraft of the blocks which make up the radar system are given in figure 49.

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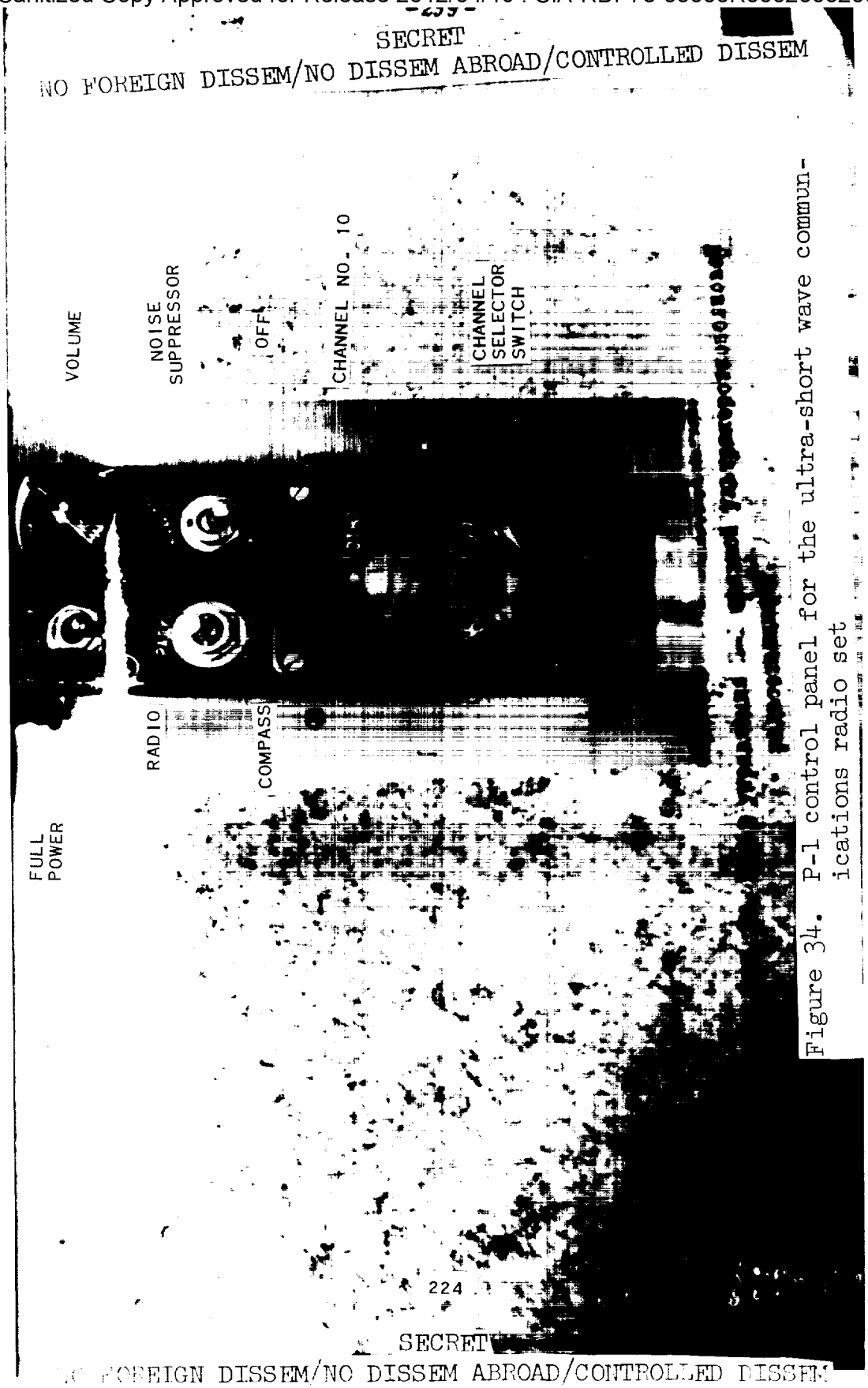

Figure 34. P-1 control panel for the ultra-short wave communications radio set

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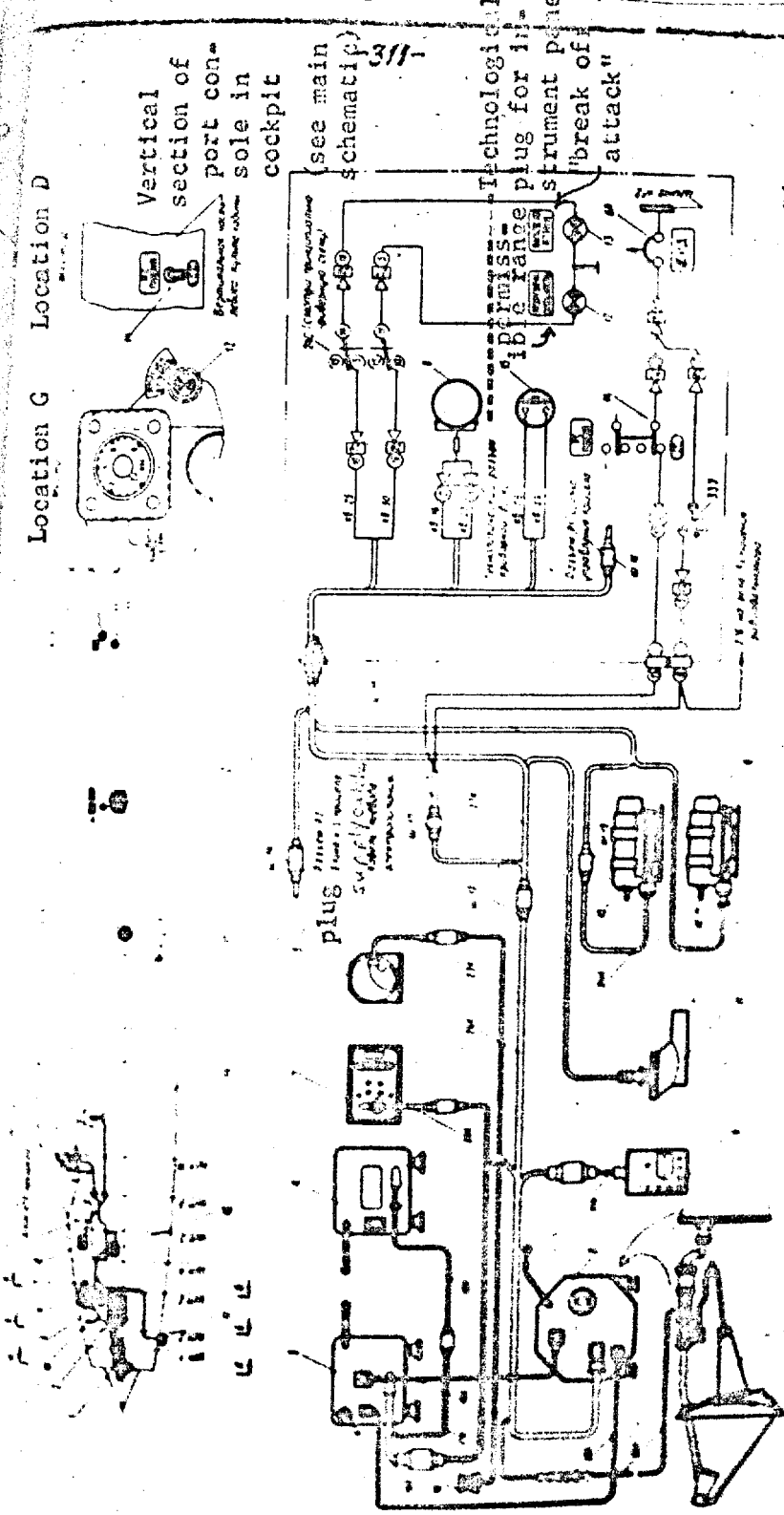

Fig. 49. Schematic of connections, and location in the aircraft, of the

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Figure 49. Schematic of connections and location in the aircraft of the range-only radar system blocks.

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Figure 49. Schematic of connections, and location in the aircraft, of the range-only radar system blocks.

1. Combination antenna and waveguide tract
2. Transceiver - block RB6-2M
3. Receiver-range meter block - block RB6-3
4. Supply block - block RB6-4
5. Speed block - block RB6-5
6. Regulator panel - block K-6
7. Comparison block - block K-8
8. Permissible range computer - VRD-2A
9. Range indicator UD-1
10. Air speed transmitter DVS-5
11. Temperature receiver P-5
12. "Permissible range" indicator light
13. "Withdraw from attach" indicator light
14. "RS, Cannon-SS" mode switch
15. Push button fro dropping target
16. Control plug

16K - 27K. Runs and feeders

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3. Principle of operation and characteristics of the antenna system of the range-only radar

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The general principle involved in measuring range to the target by the airborne/range only radar is that of automatically measuring the time between the instant a short pulse of high frequency, electromagnetic energy is radiated by the transmitter (the main pulse) and the instant some part of the energy from the pulse, reflected from the target, is received by the radar antenna. The process takes place periodically.

The airborne range-only radar sends out main pulses at a frequency of 800 ± 100 cycles per second (sic). Pulse power is from 5 to 7 kilowatts.

Because the airborne range-only radar is used in one of two ways (firing the cannon and firing unguided rockets, in one mode; launching the K-13 "air-air" class homing missiles in the other) the antenna system is made in the form of a combination of two antennas, horn and reflector, secured to a common base. The horn antenna has a radiation pattern with an 18° beam at half power for both planes (broad beam) for operation in the first mode. The reflector antenna has a radiation pattern with a 6° beam in both planes (narrow beam) for operation in the second mode. A ferrite switch, installed in the

waveguide tract of the antenna system serves to switch the antennas, forming the different radiation patterns. When the tumbler of the "RS, Cannon-SS" transfer switch, located on the vertical section of the port console, is set to the corresponding position operation of the relay in block K-6, the control panel, for switching the circuit for the ferrite switch is provided for. Thereby the ferrite switch provides for operating the antenna system either with the broad, or the narrow, beam.

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4. Range-only radar operation

The procedure of cutting in the "SRD" circuit breaker (AZS-10), located on the forward electrical switchboard on the starboard console, setting the tumbler of the "Radar-Optical" transfer switch, located on the sight head, to the "Radar" position, setting the tumbler of the "RS, Cannon-SS" transfer switch, located on the vertical section of the port console in the cockpit, to the "RS, Cannon" position, and setting the tumbler of the Gyro-Fixed" transfer switch, located on the sight head, to the "gyro" position, will result in the airborne range-only radar functioning in the mode for firing the cannon and the unguided rockets.

The receiver block - block RB6-3 - in the airborne range-only radar system produces the range pulses, displaced relative to each other, to provide for target search in range. The range pulses are fed to the coincidence stage (the time discriminator), which receives as well the pulses reflected from the target by way of

the transceiver - block RB6-2M - output.

The moment the range pulses are in coincidence with the pulses reflected from the target, the lock-on circuit functions (the green "lock-on" indicator light on the sight head lights up) and the functioning of the search circuit ceases.

The airborne range-only radar locks-on the target and shifts to the tracking mode, tracking the target in range and furnishing a voltage, proportional to the range and relative speed of the target, to the ASP-5ND - block No. 5 - sight distribution box.

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The procedure of cutting in the "SRD" circuit breaker (AZS-10), setting the tumbler of the "Radar-Optical" transfer switch to the "Radar" position, setting the tumbler of the "RS, Cannon - SS" transfer switch to the "SS" position, and setting the tumbler of the "Gyro-Fixed" transfer switch to the "Fixed" position, will result in the range-only radar system's fundtioning in the mode which will fire the K-13 "air-air" class homing missiles after having fixed the moment for effective firing.

When the tumbler of the "Gyro-Fixed" transfer switch is set in the "Fixed" position a luminous mark in the reflecting window in the sight head takes the position corresponding to the axial direction of the aircraft and sighting will take place in accordance with the fixed mark, just as would be done with a collimating sight.

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When the tumbler of the "RS, Cannon - SS" transfer switch is set in the "SS" position a mode signal is supplied to the regulator panel - block K-6 - to the winding of the relay for switching the ferrite switch circuits. When the relay operates it disconnects the voltage, proportional to the present range to the target, from the block, No. 5, in the ASP-5ND firing-launching sight, and feeds it to the comparator block - block K-8 - in the range-only radar system.

The comparator block furnishes a voltage, proportional to the present range to the target, to the UD-1 range indicator. This instrument is installed on a special bracket which is secured, by screws, to the sight's range indicator. The instrument scale is calibrated directly in kilometers.

In addition, present range voltage in the comparator block is supplied

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to the electronic comparator circuit, to which, at this same sacle, there is supplied the voltage for permissible range at which to launch missiles. This voltage is supplied by the VRD-2A permissible range computer. If the voltage for present range to target should become equal to, or less than, the voltage for permissible range at which to launch missiles (this will depend upon the aircraft altitude, actual air speed of the carrier aircraft, and the value and sign of relative target speed) the comparator circuit operates, and the green "Permissible Range" indicator light, which is mounted on a special bracket (alongside the UD-1), lights up.

Within the comparator block the present range voltage is also supplied to a special

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circuit which functions when the range voltage reaches a value equal to a distance of 1,000 meters, at which point the red "Withdraw from Attack" signal light, which is mounted on a special bracket, and which indicates danger of approaching too close to the target, lights up. The object is to avoid a collision or running into fragments from the missiles.

5. Range-only radar electrical supply circuits

The range-only radar is supplied with 27 volts, direct current, from the on-board network; with 115 volts, 400 cps, single phase alternating current from the PO-750A converter, which converts the direct current from the on-board network into 115 volts, 400 cps, single phase alternating current; and with 36 volts, 400 cps 3-phase alternating current from the PT-500Ts converter, which converts the on-board direct current into the 36 volt, 400 cps, 3-phase alternating current.

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The range-only radar can operate continuously for a period of 8 hours. Average range is 2,000 meters. The target search limits are from 300 to 3,000 meters.

Requirements for the 115 volts, 400 cps, alternating current total 360 volt-amperes. Requirements for the 27 volts direct current are 27 watts at a temperature above 0°C, and 130 watts when the temperature is below 0°C.

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The diagram showing interconnection of range-only-radar and sight schematic of the radar is shown in figure 50.

6. Location of blocks and methods for securing the blocks

The combination antenna - block K-1 - and the waveguide tract are installed in the forward section of the fuselage in the cone. The combination antenna is secured to the crossover bracket by screws and anchor nuts. The bracket is fastened to a flange in the cone funnel with bolts. The waveguide tract is fastened to an intermediate housing by four screws which enter a threaded flange. The intermediate housing is fastened to the face of frame number 2 by screws and anchor nuts.

The waveguide tract has three points at which it can be disjointed, to simplify the installation and removal.

The transceiver - block RB6-2M - is installed in the upper equipment compartment, between frames 2A and 3 on four shock mounts secured to two brackets. The brackets are fastened, on one side, by screws and anchor nuts, to a crossover bracket which is secured to frame 2A. The transceiver is secured to two straps.

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The range-only radar receiver block - block RB6-3 - and the supply block - block RB6-4 - are installed in the upper equipment compartment, between frames 2A and 3, above the

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Figure 50. Diagram showing range-only radar and sight interconnection

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Figure 50. Diagram showing interconnection of range-only radar blocks and sight

6R. AZS "SRD"

17R. Relay for energizing PO-750 and supplying DVS-5

33E. Relay for disconnecting power consumers

2N. PT-500Ts converter

17N. Relay for triggering PT-500Ts for supplying DVS-5

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transceiver (block RB6-2M), each mounted on four shock mounts secured to a common panel for the blocks. The panel is secured to two brackets by lock nuts and the brackets, in turn, are rigidly connected with the construction of frames 2A and 3.

The speed block - block RB6-5 - is installed in the equipment compartment, between frames 2A and 3, under the receiver block and is secured with screws in two tapped holes to a crossover which is secured to the panel for the receiver-range meter block and the supply block.

The control and regulator panel - block K-6 - is installed in the upper equipment compartment, between frames 2A and 3, to starboard, on a level with the RB6-3 block on a bracket which is fastened to the inlet duct

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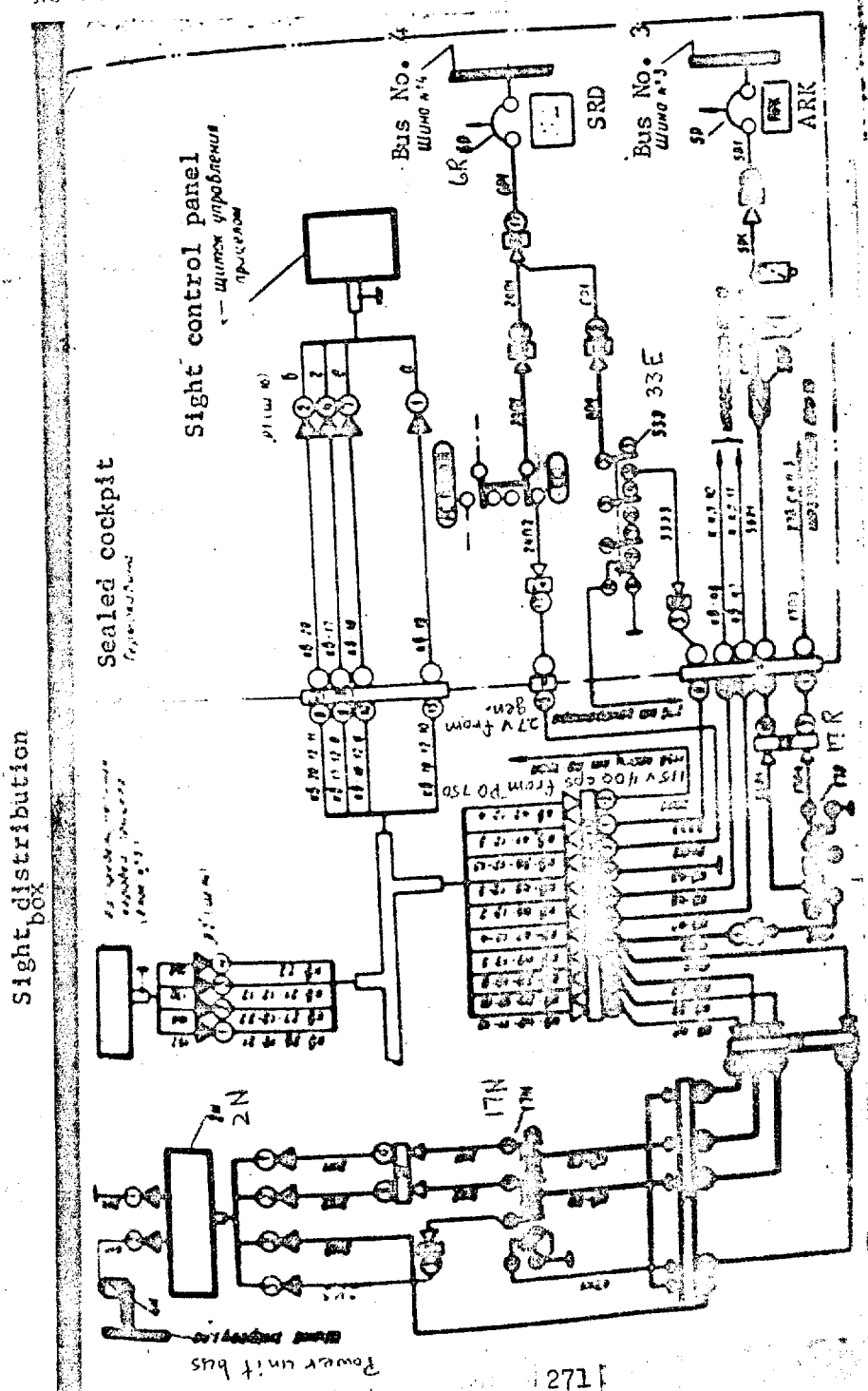

Fig. Diagram showing range-only radar and sight interconnection

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sheathing. The panel for the regulators is secured to a bracket by lugs, one of which fits into a channel in the bracket, while the other is secured to the threaded part fastened to the bracket.

The comparator block - block K-8 - is installed in the upper equipment compartment, between frames 3 and 4 (nearer frame No. 3), to port, behind the RB6-4 block on the bracket for block no. 2 of the ASP-5ND sight. The comparator block is secured to the bracket with the aid of two plates (adaptors). The plate, on one side, is secured to the bracket by screws and anchor nuts, while, on the other side the plate for the block is set in a channel in the bracket.

The permissible range computer VRD-2A is installed in the upper equipment compartment, between frames 4 and 5, but closer to frame 5, to port, behind the inertial contactor for the SRO recognition responder, on an easily removable bracket. Adjustment

and scale view is provided for.

The air speed transmitter DVS-5is installed in the equipment compartment between frames 4 and 5, to he port side, under the RSIU-5 (block ABV) transceiver, on an easily removple panel secured by screws and anchor nuts to brackets which are rigidly cnected to the aircraft frame. A portable mirror, from spare parts caied in the aircraft, is used to scan the speed transmitter scale.

The P-5 temperature receiver is installed near frame number 2, underneath, externally, and to starboard and is secured to the skin of the fuselage by four screws and anchor nuts

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The UD-1 range indicator is installed on a special bracket which is secured to the sight's range indicator by screws.

The "RS, Cannon - SS" mode transfer switch is installed on the vertical section of the port console and is secured to it by two screws.

The "Permissible Range" indicator light is installed on a special bracket next to the UD-1 range indicator.

The "Withdraw from Attack" indicator light is installed on a special bracket next to the UD-1 range indicator.

The push button for dropping the target is installed on the sight head, to port and underneath.

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Figure 51. UD-1 Range Indicator

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VI. Electrical Supply for the Radio Equipment in the MiG-21F-13 Aircraft

1. General Information

The 27 volts ± 10% direct current electrical supply for the radio equipment comes from the on-board network off busbars 2, 4 and 3 on the forward starboard and after starboard electrical switchboards through the circuit breakers installed on the forward and after electrical panels on the starboard console in the cockpit, and from the busbar of the port power unit through the IP-75M fuses installed in the power unit.

The following obtain their supply from busbar number 2 on the forward electrical switchboard of the starboard console:

the ultra-short wave radio set RSIU used for communications purposes, through AZS-5 "Radio set oil pressure" (sym. 3R);

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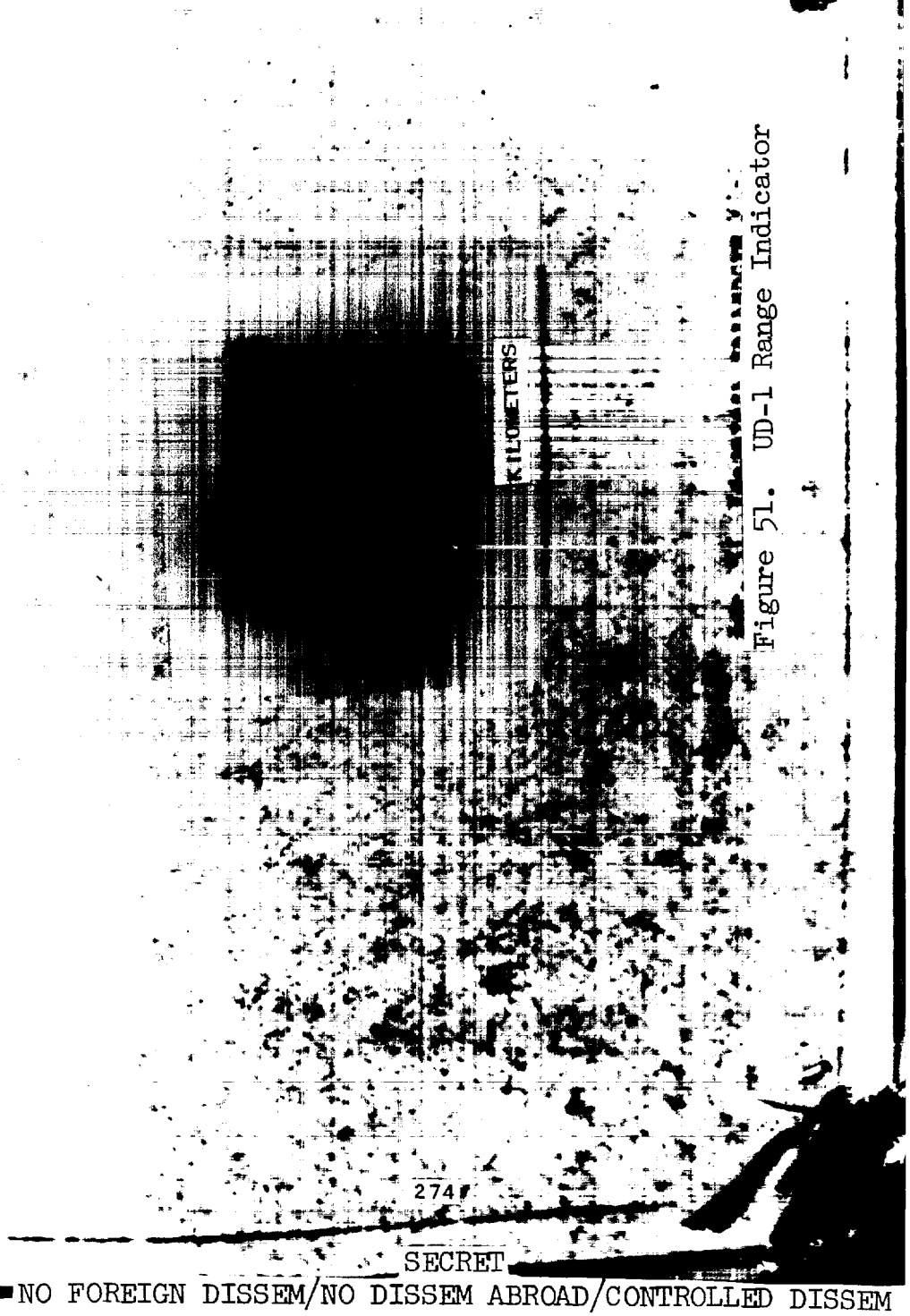

Figure 51. UD-1 Range Indicator

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the type RV-UM low altitude radio altimeter, through AZS-5 "RV-U Marker" (sym. 34R);

the MRP-56P marker radio receiver installation, through AZS-5 "Marker, RV-U" (sym. 34R);

the SRO-1 airborne radar responder, through AZS-10 "SRO" (sym. 49R).

Busbar No. 4 on the forward electrical switchboard of the starboard console in the cockpit provides the supply to the range-only radar through

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AZS-5 "SRD" (sym. 6R).

Busbar No. 3 on the after electrical switchboard of the starboard console in the cockpit provides the supply to:

the ARK-10 automatic radio compass through AZS-15 "ARK" (sym. 5R).

The 115 volts + 4 volts, 400 cycles +7% -8%, single phase, alternating current used by the ultra-short wave radio and by the ARK-10 automatic radio compass when these equipments are operating in the primary mode comes from the PO-750A converter (sym. 1R), while the supply for the range-only radar, the type RV-UM low altitude radio altimeter and the MRP-56P marker radio receiver installation comes from the PO-750A converter (sym. 2R).

In the event the PO-750 converter (sym. 1R) breaks down - emergency mode - the ultra-short wave radio set, the ARK-10 automatic radio compass obtain their supply of 115 volts, 400 cycles, single phase alternating current from the PO-750A converter (sym. 2R). When this occurs the range-only radar, the type RV-UM low altitude radio altimeter, and the MRP-56P marker radio receiver installation are disconnected from the PO-750A converter (sym. 2R). However, by setting the AZS with the marking "PO-750

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failure," "RVU,MRP" (sym. 22R), located above the forward electrical switchboard for the starboard console in the cockpit, to the "RVU,MRP" position it is possible to force energizing of the type RV-UM low altitude radio altimeter

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and the MRP-56P marker radio reciever installation.

In the event the PO-750A (sym. 2R) converter breaks down - emergency mode - the supply for the type RV-UM low altitude radio altimeter and the MRP-56P marker radio receiver installation, the 115 volts, 400 cycles, single phase alternating current, can be obtained from the PO-750A converter (sym. 1R) by setting the AZS-5 marked "PO-750 failure," "RVU,MRP" in the "RVU,MRP" position.

A relay (sym. 57R) is provided to prevent the PO-750A (sym. 2R) from starting in the event the generator breaks down, in which case the PO-750A converter (sym. 2R) is automatically disconnected, and the AZS-5 (sym. 22R) is switched to the "RVU,MRP" position. The relay (sym. 57R) functions when the AZS-5 (sym. 22R) is switched to the "RVU,MRP" position. The normally closed contacts, 1 and 2, in the relay open and break the PO-750A (sym. 2R) converter start circuit by removing "negative" from terminal 4 (the start terminal).

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VII. Aircraft Bonding

Aircraft bonding is the special electrical connection of the aircraft's metal parts and the equipment aggregates in such a way as to form a firm electrical contact between them which has low contact resistance.

The quality of the bonding reflects on the amount of radio interference,

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on the radio communications range, and determines the reliability of operation of the radio equipment installed in the aircraft.

All metallic structures and parts in the aircraft with an area of more than $0.2m^2$ or a length of more than 0.5 meter (straps, piping, shielded hose) have been bonded to the aircraft.

Bonding is done with flexible connectors manufactured in accordance with standard [Russian "normal"] 155N385; with special connectors installed in accordance with the blueprints; and directly, by contact between surfaces which have been cleaned.

The points to which the bonding connectors are fastened are cleaned (no longer than one hour prior to installation) to a metallic luster and are free of varnish, oxide, paint, anodic and grease films. The surface should have a circular or oval shaped clean area. Parts which are protected by metallic anticorrosion coverings are descaled by gasoline or white spirits using calico cloths.

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Figure 52. Typical bonded connections

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Those portions of the contact surfaces which were not cleaned are given a coating of lacquer after the bonding connectors have been fastened in place or metal parts which are in direct contact with each other have been secured in place.

Galvanized steel screws and tinned terminals are used in bonding parts of magnesium alloys. The bonding site around the terminal area, as well as the screw, is covered witha coat of lacquer.

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Металлизация экранированных кабелей

Bonding shielded cables

Сечение по А-А

Section through A-A

Cleansed surface

Fastening bonding connector

Крепление перемычки

Cleansed surfaces

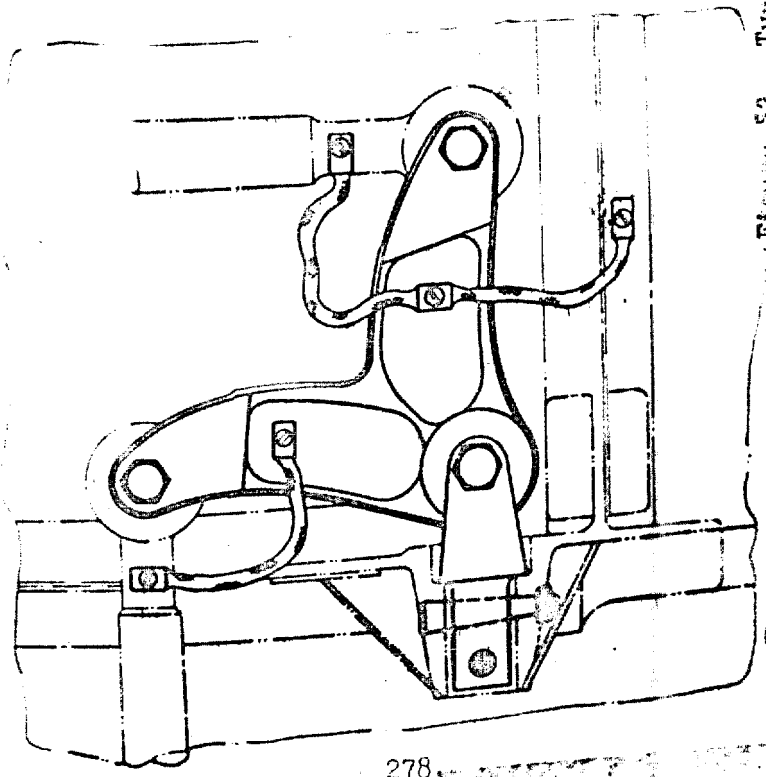

Figure 52. Typical bonded connections

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The quality of the bonding process for the units and aggregates is determined by measuring the contact resistances for the bonding.

Figure 52 shows typical bonding connections.

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VIII. Static electricity discharge installation

At high flight speeds, because of the friction of the mass of air on the surface of the aircraft, the latter is heavily electrified, so that the potential difference for individual sections of the aircraft can attain values of several thousands of volts. In this connection, improper bonding of the aircraft can give rise to electrical discharges which cause interference in the radio and radar equipments. Dischargers have been installed on the trailing edges of the wings, as well as on the stabilizers and tail fin, in order to discharge the static electricity into the atmosphere.

The schematic showing the location of the static electricity dischargers on the aircraft is given in figure 53.

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Chapter III

Instrumentation

1. General information

Aircraft instrumentation is such as to permit the aircraft to fly day or night, under all types of weather conditions, at any altitude up to service ceiling. Instrumentation resolves the following questions:

orientation of the aircraft in space and along its course;

operational monitoring of the engine, guns, rockets, and radio equipment;

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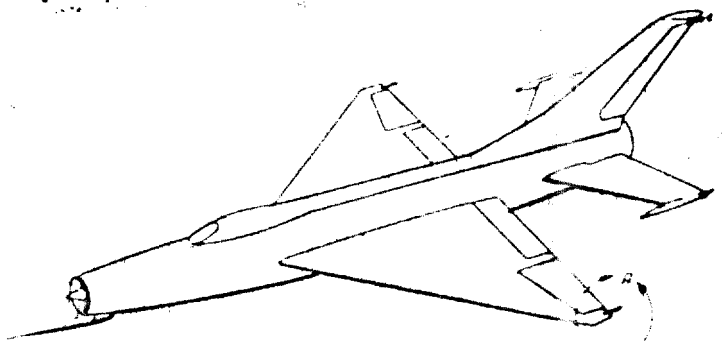
38. УСТАНОВКА РАЗРЯДНИКОВ СТАТИЧЕСКОГО ЭЛЕКТРИЧЕСТВА.

При больших скоростях полета, из-за трения масс воздуха о поверхность самолета, последний сильно электризуется, причем разность потенциалов отдельных участков самолета может достигнуть значения в несколько сот тысяч вольт. В связи с этим, при недостаточно надежной металлизации самолета, могут возникнуть электрические разряды, вызывающие помехи при работе радиоаппаратуры. Для отвода статического электричества в атмосферу на задних кромках крыла и стабилизаторов, а также на фюзеляже установлены разрядники.

Схема размещения разрядников статического электричества на самолете дана на фиг.53.



Location A

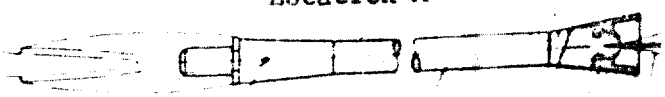


Figure 53. Discharger location schematic

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providing and checking conditions required in the cockpit to enable the pilot to function normally.

Instrumentation consists of:

(a) piloting and navigational instruments;

(b) instruments for monitoring engine operation;

(c) instruments for monitoring operation of individual aggregates and systems in the aircraft.

All instruments are located in the cockpit. Instrument location has been subordinated to the desire to retain good visibility from the pilot's seat in all directions and to provide maximum convenience of operation in the air in the face of handling a great many command and monitoring instruments needed for the normal operation of the aircraft.

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All indicating, measuring, and regulating devices are listed in three groupings, according to position in the cockpit:

equipment concentrated on the instrument panel, and in locations directly adjacent to it;

equipment installed on the port console and along the port side of the cockpit;

equipment installed on the starboard console, and along the starboard side of the cockpit.

The middle panel is installed below the instrument panel.

For night flying all knobs and control levers, instrument needles, and inscriptions have been painted with luminous material.

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In order to ease the work load on the pilot the instrument scales have been divided into colored sectors which indicate the various operation modes for the aggragates as follows:

(a) bule sector - unrestricted operational mode;

(b) yellow sector - Attention! but operation is permissible;

(c) red sector - operation in this mode is forbidden.

The technical data on instruments, presented in this chapter, have been taken from the data certificates for these instruments.

Cockpit dimensions, as well as the manner in which the instrumentation is laid out, ensure that the pilot can be safely ejected in event of an emergency situation.

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Figure 54. Aircraft Instrumentation

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Figure 55. Schematic of zone division in the cockpit

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Air Navigation Instruments	Engine Instruments Parameters monitored	Individual systems and aggregate Instruments
1. Speed	1. Engine rpm	1. Hydraulic system pressure
2. Altitude	2. Fuel consumption	2. Air system pressure
3. Overload	3. Oil pressure	3. Pressure drop and "altitude" in cockpit
4. Course	4. Signals	4. Oxygen system pressure
5. Position of horizon	5. Gas temperature after turbine	5. Storage battery capacity
6. Bank and turn		6. Signals
7. Time		
8. Rate of climb		

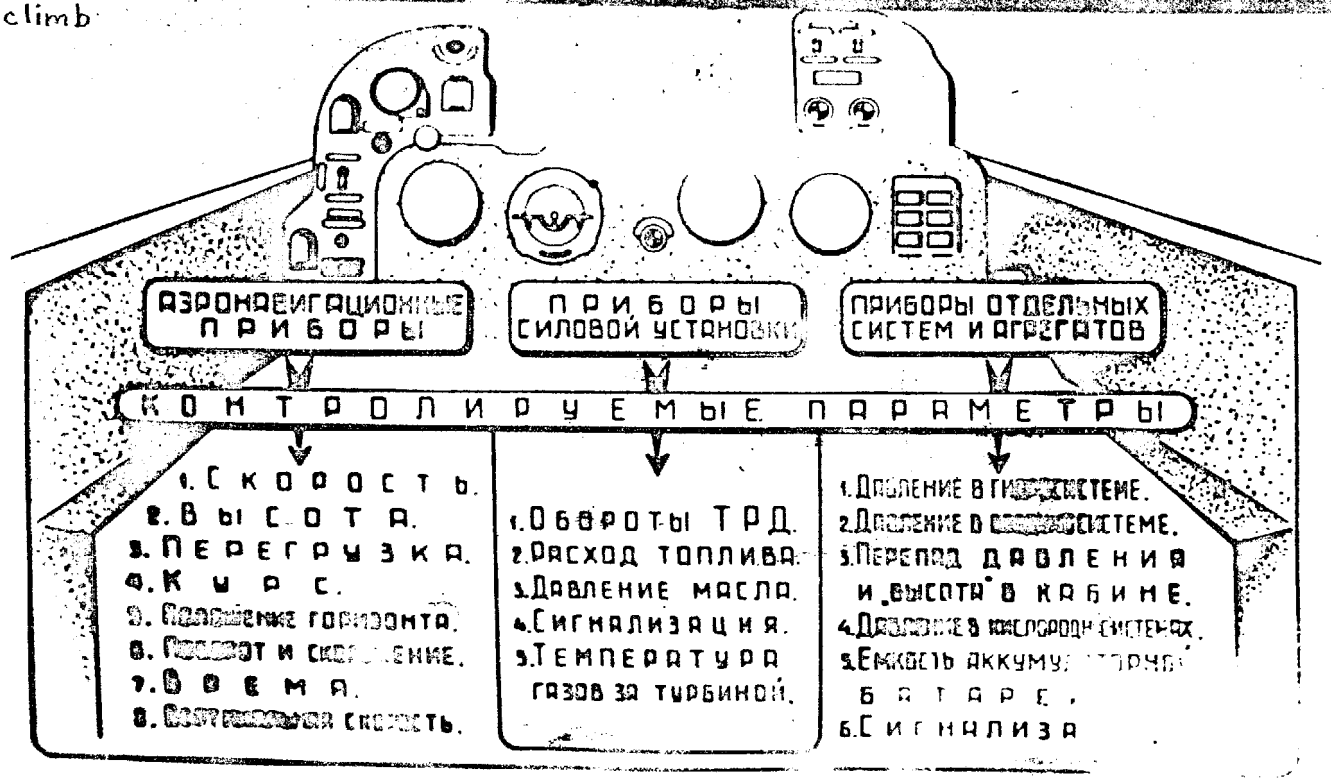

Figure 54. Aircraft instrumentation

Фиг.54. Приборное оборудование [illegible]

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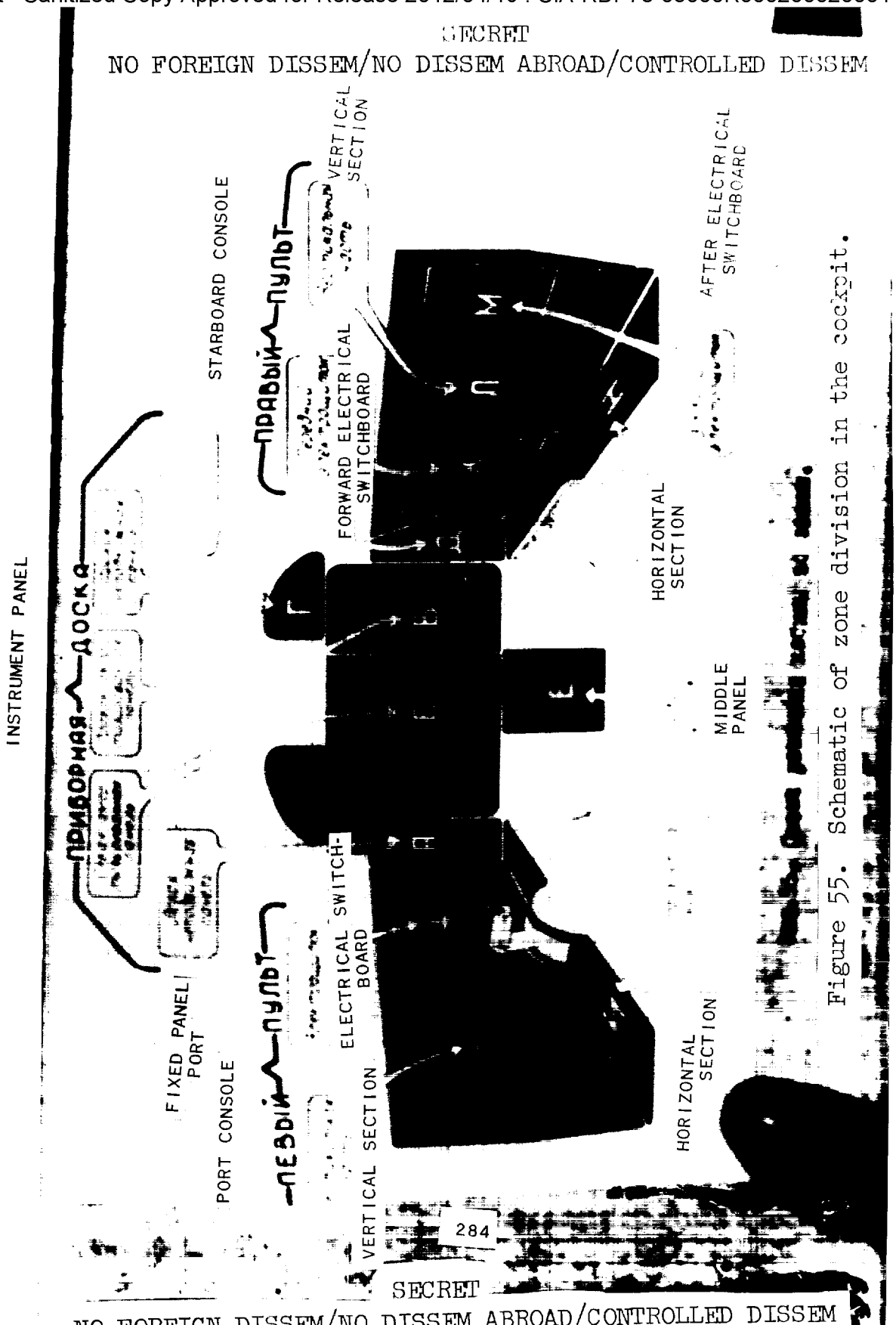

Figure 55. Schematic of zone division in the cockpit.

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Aircraft Cockpit Instrumentation

(Figure 55)

(Translator's Note: This table has seven columns but Column 1 is illegible and is not included).

No.	Designation	Type	No. in a/c	Operating principle	Note
2	3	4	5	6	7
1	Cannon reload button	5KS	1		
2	Button for emergency drop of RS, APU, SS	205KS	1		Under a protective cover
3	Accelerometer	AM-10	1	Mechanical	
4	Parachute stream button	5KS	1		Under protective cover
5	Button for cutting in canopy deicer	5KS	1		
6	Emergency wheel brake knob		1		Red
7	Transfer switch for homing stations "short-long"	PP-45	1		
8	Transfer switch for controlling landing and taxi lights	VT3602020SP			

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2	3	4	5	6	7
9	Button for dropping suspended tank	20AKS	1		Under protective cover
10	Arm position indicator, automatic control	AN4-3V	1	Electrical	
11	Transfer switch for lowering and raising landing gear		1	Electrical	
12	Combination indicator for oxygen supply and flow	MK-18	1	Manometer	
		Page 336			
13	Piloting and landing signal device, cuts in signals for:	PPS-2	1	Electrical	
	(a) lower landing gear;		1		Red
	(b) flaps down		1		Green
	(c) speed brakes down		1		Green
	(d) signal lights for landing gear:				
	up		3		Red
	down		3		Green
1	Combination speed indicator	KUS-2500	1	Barometric	
2	Combination indicator for magnetic compass and radio compass	UGR-4U	1		KSI complex
3	Push button for matching KSI	5K	1		

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2	3	4	5	6	7
4	Radio altimeter indicator	UV-57	1		RV-UM complex
5	Dangerous altitude signal light	SLTs-51 (SM-30)	1		Red
6	Knob for cutting in nose wheel brake				
7	Master attitude indicator	AGD-1	1	Gyroscopic	
8	Altimeter	VD-28	1	Barometric	
9	Signal display for cutting in signals for:	T-4	1		
		Page 337			
	(a) marker				Red
	(b) cone released				Green
	(c) landing stabilizer				Green
	(d) trim effect neutral				Green
10	Clocks	AChKh	1	Mechanical	
11	Climb indicator	VAR-500	1	Barometric	
12	Back up signal light for "lower landing gear!"	SLTs-51 (SM-30)	1		Red
13	Electrical turn indicator with bank indicator	EUP-658	1	Gyroscopic	

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2	3	4	5	6	7
14	Oil pressure indicator in engine	UI-1-8	1	Manometer	DIM-8T complex
15	Circuit breaker for clock and PVD heaters	AZS-20	2	Automatic thermal	
16	Combination indicator for "altitude" and pressure drop in cockpit	UVPD-20	1	Manometer, barometric	
17	Signal light for "BPRS" near-homing radio set	SLTs-51 (SM-30)	1		Green
1	Mach number indicator	M-2,5	1	Manometer	
2	Electrical induction, two-needle tachometer	ITE-2	1	Electrical	

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3	Exhaust gases thermometer	TVG-11T	1	Thermal-electrical	
4	Signal display, with signals for:	T-6	1	Electrical	
	(a) afterburner				Green
	(b) start engine				Green
	(c) service tank				Red
	(d) fire				Red
	(e) generator out				Red
	(f) 500 liters remaining				Red

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2	3	4	5	6	7
5	Signal lights for operation of pumps, tanks 1-3	SLTs-51 (SM-30)	2		Green
6	Flow meter-fuel guage	RTS16A-4	1	Electrical	
7	Signal lights for drop in pressure in main and booster hydraulic systems	SLTs-51 (SM-30)	2		Yellow
8	Dual electrical manometer for booster and main hydraulic systems	2EDM-250	1	Electrical	
9	Push button for SS emergency launch	204KS	1		Under red cover

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1	Signal light indicating SS suspended in racks	SLTs-51 (SM-30)	2		Green
2	Transfer switches for different ways to launch SS "volley-single," "port-starboard"	87K 2PPN-45	1 1		

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2	3	4	5	6	7
1	Voltmeter	V-1	1	Electrical	
2	Integrating counter, storage battery ampere-hours	ISA	1	Electrical	
	MIDDIE PANEL				
2	Signal light, cannon ready to fire	SLTs-51 (SM-30)	1		Red
4	Signal light, RS, APU suspended	SLTs-51 (SM-30)	2		Green
	Page 340				
5	Signal light, suspended tank in place and fuel being taken from it	SLTs-51 (SM-30)	2		Green
6	Dangerous altitude transfer switch	PSV-U	1		RV-U complex

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2	3	4	5	6	7
7	Indicator, excess oxygen pressure in mask or sealed helmet	M-2000	1	Manometer	
8	Indicator, air pressure control, main landing gear brake system	MV-12	1	Manometer	Dual needle
9	Fuses, ARK-10	SP-5 SP-10	1 1	Thermal	
	PORT CONSOLE				
1	Circuit breaker, fire equipment, deicer, and fuel sluice valve	AZS-5	1	Automatic, thermal	
2	Circuit breaker, VDM hydraulics, signalling suspended and service tank depletion	AZS-5	1	ditto	
3	Circuit breaker, pumps (a) 1 and 3	AZS-5	2	ditto	
4	Push button for cutting in fuel sluice valve	204KS	1		Under protective cover

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2	3	4	5	6	7
5	Circuit breaker, for cutting out wheel brake automatic device	AZS10	1	Automatic, thermal	

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6	Circuit breaker, for starting aggregates	AZS-25	1	Automatic, thermal	
7	Circuit breaker, EUP, KDS	AZS-5	1	ditto	
8	Circuit breaker, for cutting in afterburner	AZS-15	1	ditto	
9	Transfer switch for cold engine roll-over during starting procedure on the ground	2V-45	1		
1	Switch, emergency nozzle control	87K	1		
2	Transfer switch, by-pass air flap control	PPN-45	1		
3	Circuit breaker, starting in air	AZS-10	1		

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2	3	4	5	6	7
4	Control panel, USM comm-unications radio set	P-1	1		RSIU complex
5	Wave transfer switch, remote		1		ARK-10 complex
6	Rheostat for adjusting audible signal when SS heads lock-on target		1		
7	Transfer switch for variations in firing rockets	VT6 6020 20SP	1		
8	Transfer switch, ARU-3V operation mode	2PP-45	1		ARU-3V complex
9	Transfer switch, manual control ARU-3V	PN-45M	1		
10	Rheostat, sealed helmet heater	RKo-45	1		KKO complex
		Page 342			
		SP-2	1	Thermal, electric	
11	ANO fuse				
12	Push button, rapid sealed helmet heat	204KS	1		KKO complex

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2	3	4	5	6	7
13	Transfer switch for brilliance of navigational lights	PZPN-20	1		
14	Transfer switch, seat control "up-down"	PN-45	1		
15	Transfer switch "RS cannon-SS"	88K	1		
16	Push button, parachute jettison	204KS	1		Under protective cover
17	Knob for switching PVL valve from main to emergency system	MK-14			
18	Manometer for oxygen makeup for engine	MK-16		Manometer	
19	Oxygen guage	KP-84			KKO complex
20	Oxygen valve	KV-2IS			KKO complex
1	Push button for starting engine on the ground	204KS	1		Under protective cover

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2	3	4	5	6	7
2	Transfer switch for extending cone at 1.5 and 1.9, and rigging in	VT360202OSP	1		
3	Transfer switch, cone control mode, manual or automatic	2PP-45	1		Under protective cover
4	Aileron booster switch	68K	1		
		Page 343			
5	Push button for cutting in fire extinguisher	205KS	1		Under protective cover
6	Engine control lever, with positions STOP, LOW GAS, RATED; MAXIMUM, MINIMUM, and FULL AFTERBURNER				
7	Push button for cutting in USW communications transmitter	204KS	1		On the RUD
8	Crank for extending and retracting speed brakes		1		ditto
9	Handle for potentiometer for manual range input to ASP-5ND sight		1		ditto

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2	3	4	5	6	7
10	Panel for lowering and raising flaps	MZ-1	1	Electrical	
11	Remote control panel, oxygen guage	DU-2	1		KKO complex
12	Shutoff valve, oxygen makeup for engine	KV-2M5	1		
13	Automatic device for G-suit with filter	AD-5A	1		KKO complex
14	Amplifier	UK-2M	1		RSIU complex

STARBOARD CONSOLE

1	Switch, on-board storage batteries and airfield supply	2V-45	1	
		Page 344		
2	Switch, generator	87K	1	
3	Switch, pump station	87K	1	

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2	3	4	5	6	7
4	Switch, stabilizer trim effect	87K	1		
5	Circuit breaker, AGD-1 master attitude indicator	AZS-5	1	Thermal, automatic	
6	Circuit breaker, KSI course system	AZS-10	1	ditto	
7	Circuit breaker, marker and radio altimeter	AZS-5	1	ditto	
8	Circuit breaker, communications radio set and lube oil pressure	AZS-5	1	ditto	
9	Circuit breaker, responder	AZS-10	1	ditto	
10	Circuit breaker, emergency transfer, converter	AZS-5	1	ditto	
11	Circuit breaker, landing light and external indication for landing gear	AZS-5	1	ditto	
12	Circuit breaker, sight	AZS-10	1	ditto	
13	Circuit breaker, sight heater	AZS-20	1	ditto	

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2	3	4	5	6	7
14	Circuit breaker, SRD range-only radar	AZS-10	1	ditto	
		Page 345			
15	Circuit breaker, infrared eye	AZC-10	1	ditto	SIV-52
16	Circuit breaker, rocket missiles RS	AZS-10	1	ditto	
17	Circuit breaker, cannon	AZS-10	1	ditto	
18	Circuit breaker, FKP	AZS-5	1	ditto	
19	Circuit breaker, SS heater	AZS-20	1	ditto	
20	Circuit breaker, SS filament	AZS-10	1	ditto	
21	Circuit breaker, SS launch	AZS-10	1	ditto	
22	Signal light, RS zero position	SLTs-51 (SM-30)	2		
23	Circuit breaker for disconnecting supply to RVU and MRP in event of PO-750 breakdown	AZS-5	1	Thermal, automatic	

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2	3	4	5	6	7
1	Automatic radio compass control panel	ARK-10	1		ARK-10 complex
2	Cockpit light on bracket	KLSRK-45	1		
3	Radar responder control panel		1		SRO complex

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4	Rheostats for cutting in UFO lights	RUFO-45	2		
5	Receptacle for portable light	47K	1		
1	Circuit breaker, emergency drop RS, tank, APU, emergency launch SS	AZS-10	1	Thermal, automatic	
2	Circuit breaker, ARU manual control	AZS-5	1	ditto	
3	Circuit breaker, ARU automatic control	AZS-5		ditto	
4	Circuit breaker, cannon, RS, SS and FKP	AZS-5	1	ditto	

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2	3	4	5	6	7
5	Circuit breaker, for RS APU suspended signal	AZS-5	1	ditto	
8	Circuit breaker, ARK-10 radio compass	AZS-15	1	ditto	
		Page 347			
9	Circuit breaker, display lamp check , fuel remaining and stabilizer trim effect indicators	AZS-5	1	ditto	
10	Circuit breaker, landing gear and ANO indicators	AZS-5	1	ditto	
11	Circuit breaker, speed brakes	AZS-5	1	ditto	
12	Circuit breaker, for cutting out booster system and gyro system indicator	AZS-5	1	ditto	
13	Circuit breaker, flaps and landing gear	AZS-5	1	ditto.	

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2	3	4	5	6	7
14	Circuit breaker, UFO, portable light and KKO and AGD heaters	AZS-5	1	ditto	
15	Circuit breaker, cockpit heater	AZS-5	1	ditto	
16	Circuit breaker, throttle and cone interlock	AZS-10	1	ditto	
17	Circuit breaker, seat "SK"	AZS-10	1	ditto	
	Page 348				
18	Circuit breaker, drag chute	AZS-5	1	ditto	
1	Dual-needle manometer, main and emergency air systems	2MI50	1	Manometer	
2	Valve handle, emergency lowering landing gear		1		
3	Panel with "exploder" push button		1		
4	"Distress" transfer switch				
5	Transfer switch for cabin heater with positions "hot," "cold," and "automatic"	P2NPN-45	1		

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2	3	4	5	6	7
6	Radio compass tuning indicator	Ammeter	1	Electrical	
7	Cockpit supply valves		1		
8	Push button for disconnecting booster system	204K	1		Under protective cover
9	Storage battery ground heater cut-out switch	67K	1		
10	Cockpit ground ventilation transfer switch	PPN-45	1		

11	Remote resistance for adjusting generator voltage	VS-20	1		
12	Circuit breaker for K2-717 self-recorder	AZS-5	1	Thermal, Automatic	

AIRCRAFT CONTROL LEVER (STICK)

1	Wheel brake control		1		
2	Transfer switch for controlling stabilizer trim effect	PK-4	1		
3	Push button for damping zero gyroscope in the ASP-5ND sight	204K	1		

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2	3	4	5	6	7
4	Push button for extending and retracting the speed brakes	204K	1		
5	Index mark for weapon control		1		
	ABOVE INSTRUMENT PANEL				
1	Sight head	ASP-5ND	1		
2	Sight range indicator		1	Electrical	
3	Range indicator	UD-1	1	Electrical	Complex
4	"Break off attack" signal light	SLTs-51 (SM-30)	1		Red
5	"Permissible range" signal light	ditto	1		Green
6	Overload signal light	ditto	1		Red
	Page 350				
7	"Fire" transfer switch		1		
8	"RS - NR-30" transfer switch		1		
9	"Altitude - DUAS" transfer switch		1		
10	"Radio - optics" transfer switch		1		
11	Range-only radar high voltage signal light	MN-5	1		Re

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2. Cockpit layout

A. Instrument panel

The instrument panel is installed in the plane of frame no. 7B. Mounted on the instrument panel are the most important, and necessary, instruments used by the pilot in constantly controlling the attitude of the aircraft in space, as well as the operation of the power plant in flight. The instrument layout, as well as the layout of other elements used for control, on the instrument panel is shown in figure 56.

The instrument panel consists of five duralumin stampings, two of which are shock mounted. The other three are rigidly secured to the sides, as shown in figure 57.

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Panels 1 and 15 are mounted in a tubular steel framework and are secured by special nuts 5 to screws 6. The steel framework is, in turn, suspended through four shock mounts 2 from brackets.

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Figure 56. Instrument panel

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Figure 57. Instrument panel design

1 - Panel B; 2 - Standard rubber shock mounts; 3 - Panel A; 4 - Tubular framework; 5 - Special nut; 6 - Screw; 7 - Sight head bracket; 8 - Panel G; 9 - Support; 10 - sleeve; 11 - dowel; 12 - guide; 13 - stop ring; 14 - Panel D; 15 - Panel

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When the nut 5 are unscrewed the panel is easily removed inside the cockpit, providing an access to the electrical plugs, the hose connections, the instruments and the equipment located on the instrument panel.

In addition, Panel 1 is made so that it can be pulled out on two dowels, or pins, 11.

The tubular dowel, or pin, can be moved in the guide 12, its movement limited, however, by stop ring 13. If this latter is pulled out the panel can be completely removed.

Panels 3, 8, and 14 are rigidly secured in place along frame number 7B with screws and are made so that they can be removed. The locations of panels 3, 8, and 14 are clearly shown in figure 57.

A white, painted stripe in the middle of the instrument panel is used to determine the neutral position of the stick in the transverse direction for aileron control.

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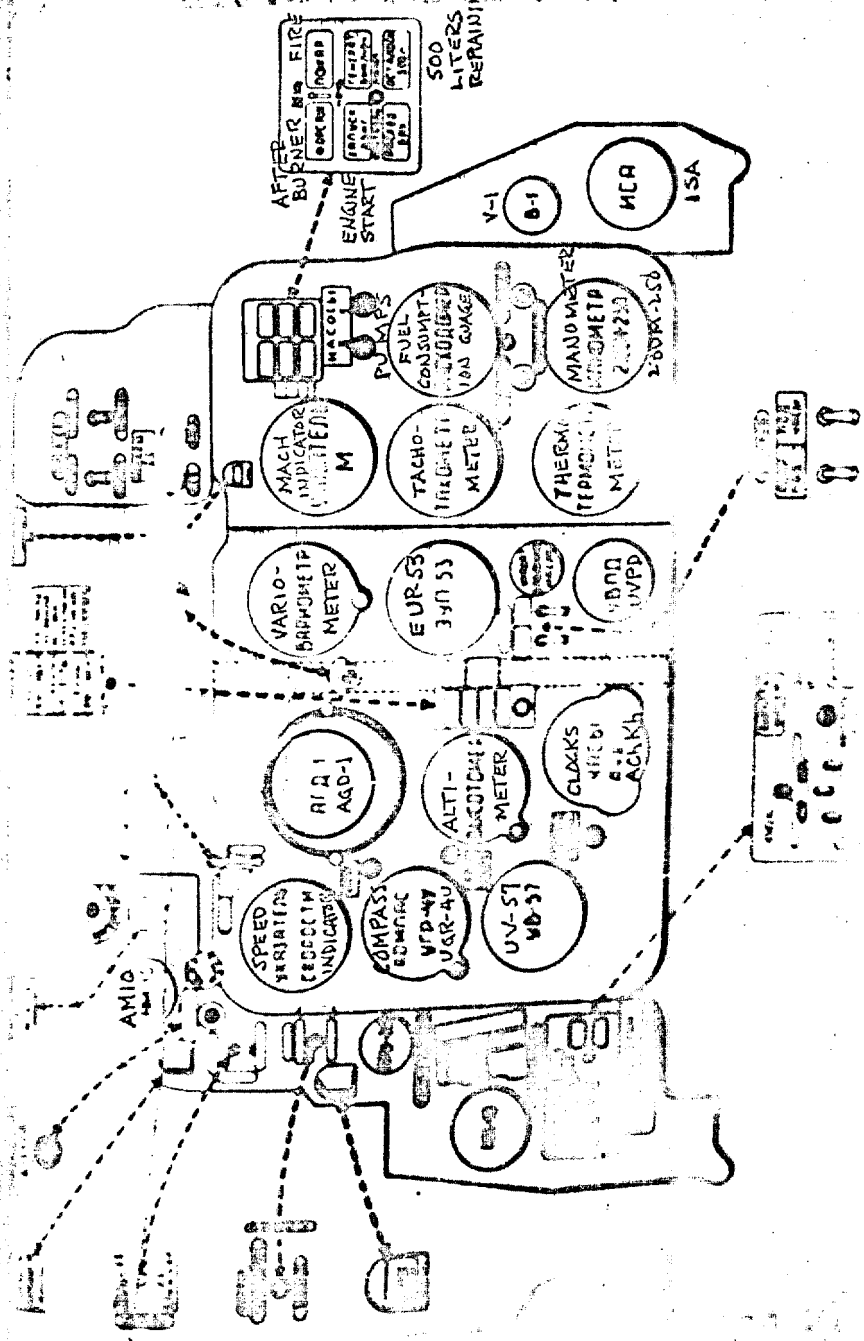

FIG. 56 INSTRUMENT PANEL

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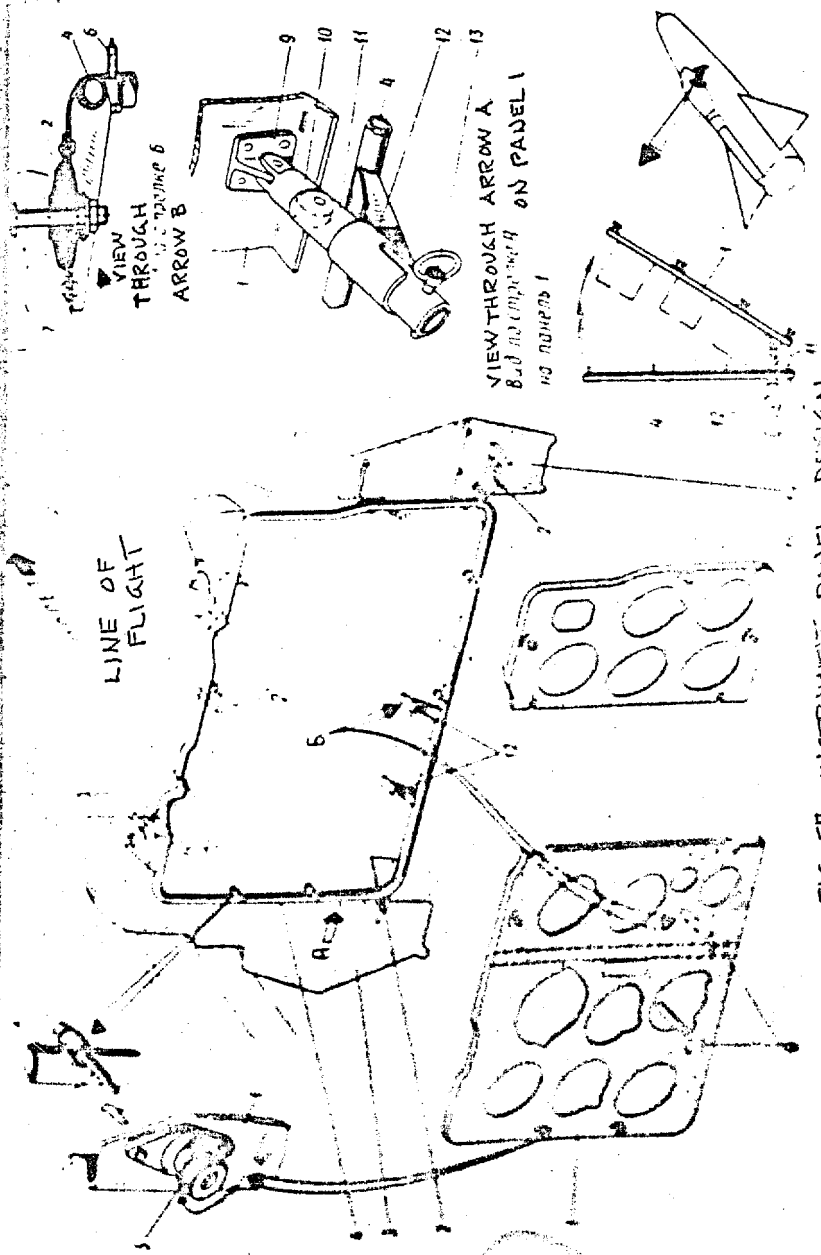

FIG. 57 INSTRUMENT PANEL DESIGN

(SEE TEXT)

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B. Middle panel

The middle panel is set underneath the instrument panel along the aircraft axis and is tilted towards the pilot at an angle of 35° from the vertical.

Figure 58 shows the location of the equipment elements on the panel.

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Figure 58. Middle panel

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Figure 59. Middle panel design

1 - Channels; 2 - Tubular steel framework; 3 - Threaded tube; 4 - Panel Ye; 5 - screw

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The panel is a stamped duralumin piece (see figure 59) which is secured in place with four self-locking screws 5 to the frame 2.

The frame 2 is made of welded steel tubing and is set in the channel 1 on the cockpit floor.

Four steel sleeves 3, threaded to take the screws 5, are welded to frame 2. This installation makes for a secure fastening of the panel to the aircraft structure.

C. Port console

The port console is positioned along the port side of the cockpit, between frames nos. 7B and 10. Mounted on the console are the units used to control the engine, fuel system, fire extinguisher, armaments, and other equipment. Instrument placement on the console is shown in figure 60.

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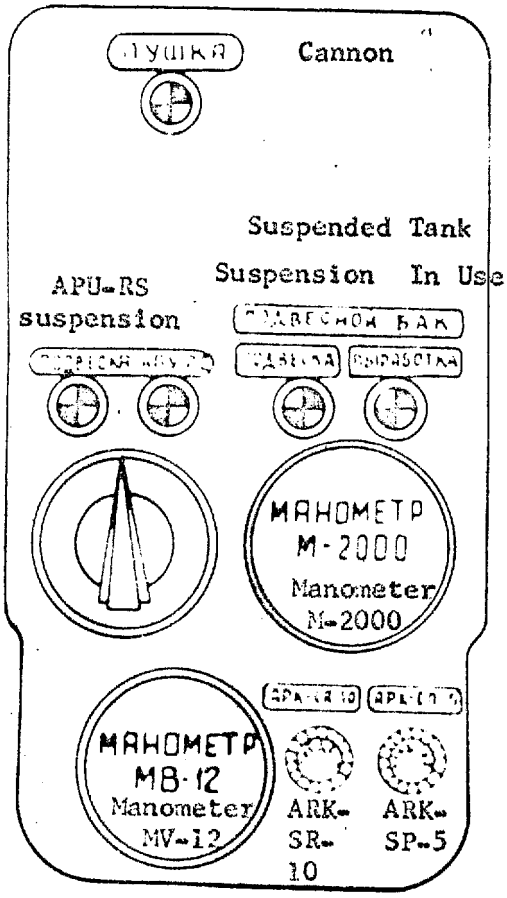

Figure 58.
Middle panel

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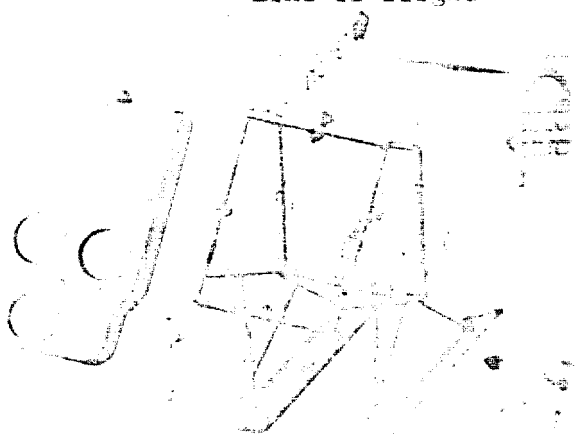

Figure 59. Middle panel design

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The console consists of a vertical and a horizontal section (see figure 61). The vertical section includes three removable duralumin panels (2, 3, 4) which are fastened to the side along the fname with special screws.

Horizontal section 1 is made as a fixed section and is secured in place with ordinary screws to the tubular steel frame installed on the side of the cockpit. A sufficiently clear outline of the console design is shown in figure 61.

D. Starboard console

The starboard console is positioned along the starboard side of the cockpit, between frame nos. 7B and 10. Mounted on the console are the forward and after

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Figure 60. Port console

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Figure 61. Port console design

1 - Horizontal panel; 2 - after panel; 3 - middle panel; 4 - forward panel; 5 - electrical switchboard

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Figure 62. Starboard console

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Figure 63. Starboard console design

1 - After panel; 2 - Middle panel; 3 - Horizontal panel; 4 - forward panel; 5 - forward electrical switchboard; 6 - ARK-10 control panel; 7 - SRO control panel; 8 - after electrical switchboard

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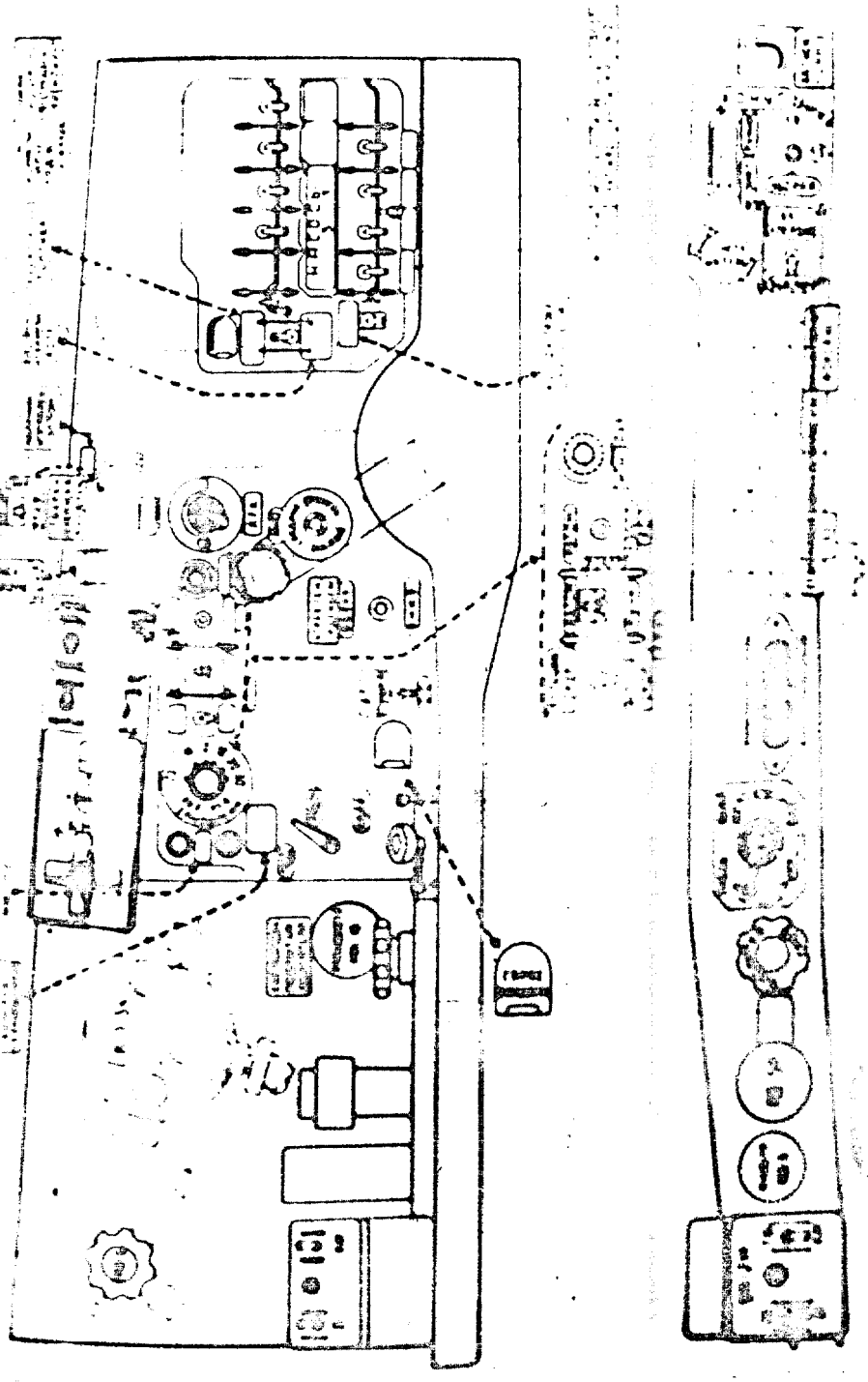

Figure 60. Port console

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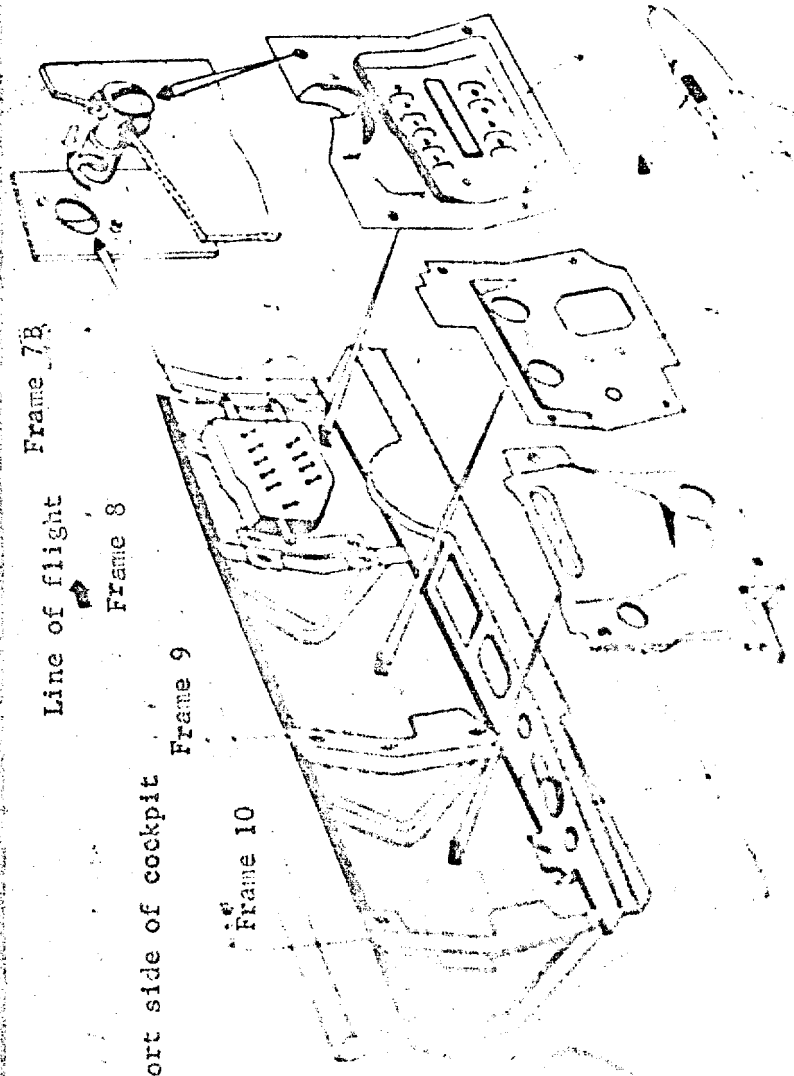

Figure 61. Port console design (see text for legend)

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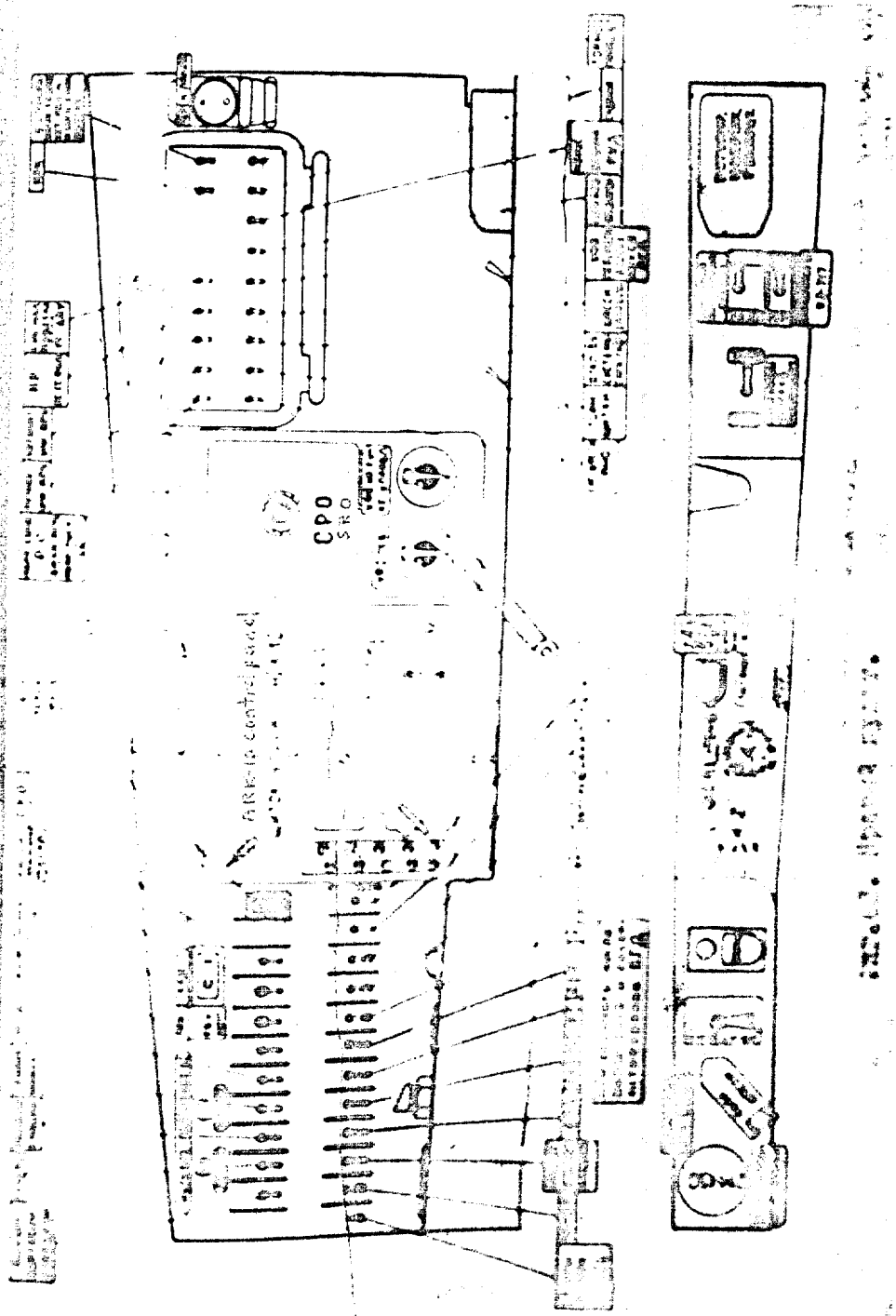

Figure 62. Starboard console

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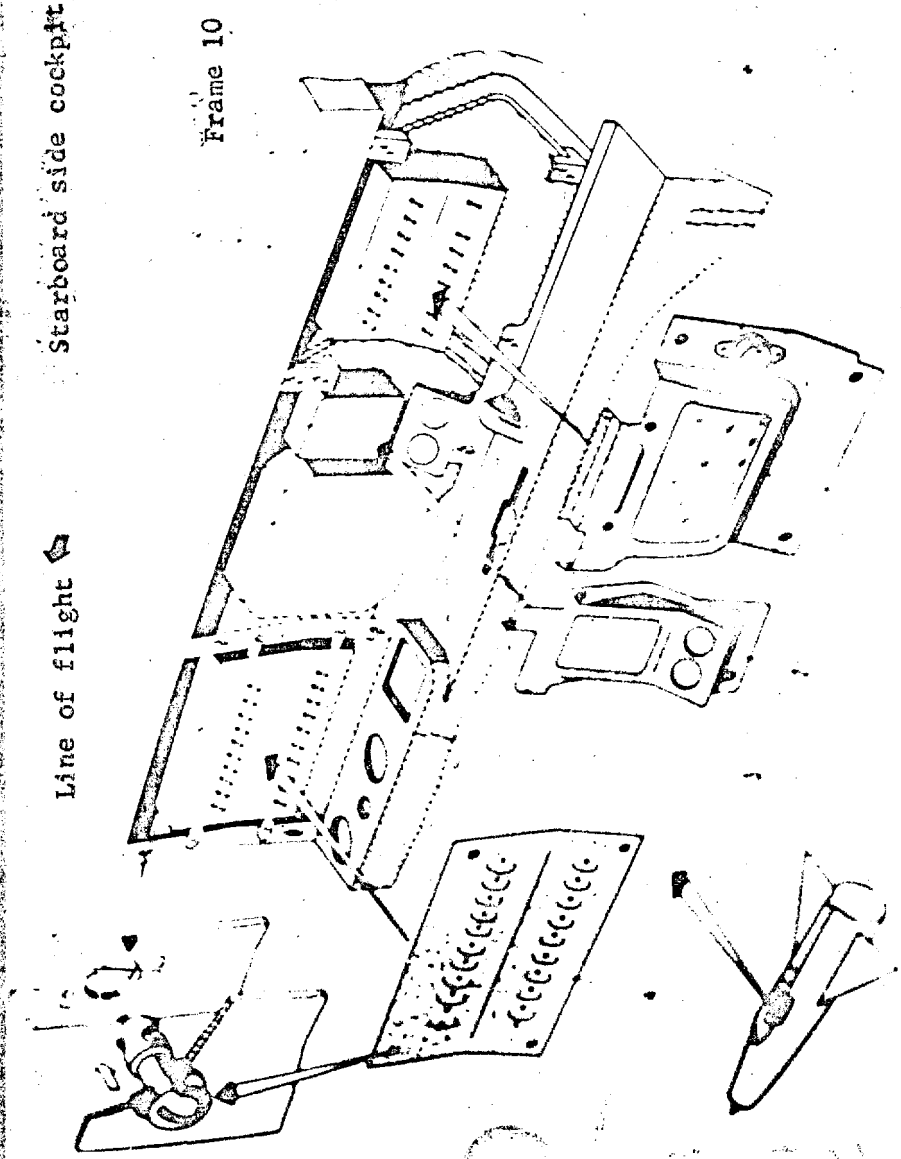

Figure 63. Starboard console design (see text for legend)

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electrical switchboards, the control panels for the radio equipment, transfer switches, valves, and other apparatus. The instrument layout on the console is shown in figure 62.

The console consists of a vertical and a horizontal section (see figure 63). The vertical section contains three removable duralumin panels (1, 2, 4), which are secured to the side along the frame with special screws.

There is, on panel 1, a transparent, hinged cover which serves to protect the circuit breakers on the after electrical switchboard from being accidentally moved by the pilot in flight.

The horizontal section 3 is made up of three fixed, duralumin panels which are secured to the tubular steel frame by ordinary screws.

Figure 63 shows the console design quite clearly.

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3. Piloting and navigating instruments

The piloting and navigating instruments permit the pilot to use, correctly and completely, the flight and tactical capabilities of the aircraft.

All instruments which assist in checking the attitude of the aircraft in space, relative to the ground, and which are used in navigating, belong to the piloting and navigating instrument grouping.

Included in this group of instruments are:

A. the KUS-2500 combination speed indicator;

B. the AGD-1 master attitude indicator (gyrohorizon)

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C. the KSI fighter plane course system;

D. the VD-28 two-needle altimeter;

E. the EUP-53 electrical turn indicator;

F. the AChKh3 aviation clock;

G. the VAR-500 climb indicator;

H. the "M" number indicator (M-2.5)

I. the UV-57 indicator of the RV-UM radio altimeter;

J. the ARU-3V arm position indicator;

K. the overload indicator for the AM-1o accelerometer

The instruments operate on various principles. Some of the air navigation instruments operate off the PZD system, on the principle of the measurement of dynamic and static pressures in flight. The operation of others is based on the radio engineering, electrical and gyroscopic principles for the particular device.

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A. The KUS-2500 Combination Speed Indicator

The instrument is designed to measure the forward speed of the aircraft relative to the air mass and is expected to indicate within the range from 200 to 2500 kilometers per hour at flight altitudes from 0 to 25 kilometers. Instrument operation is based on the measurement of the difference between the absolute dynamic and static pressures of the air in flight, that is, the velocity head and the pressure of the ambient, together with the introduction of methodical corrections for air density for altitude, determined with the aid of an aneroid device.

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For reading purposes the instrument has only one scale, calibrated from 200 to 2500 kilometers per hour with divisions every 20 kilometers per hour up to 400 kilometers per hour, and every 50 kilometers per hour from 400 up. The meter has two needles. One needle (the broad one) indicates indicated flight speed in the range from 200 to 1800 kilometers per hour, while the other (the narrow one) indicates true air speed in the range from 400 to 2500 kilometers per hour. See figure 64.

Figure 64. KUS-2500 speed indicator.

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B. The AGD-1 Remote-Indicating Master Attitude Indicator

A new master attitude indicator has been installed in the aircraft.

The AGD-1 master attitude indicator, with slip indicator, is designed to determine the attitude of the aircraft in space relative to the plane of the true horizon when the ground is not visible. In addition, the master attitude indicator determines the presence of, and the direction of, lateral slip of the aircraft.

In the well-known AGI-1 master attitude indicator the indication elements are mechanically linked to the gyroscope, making it difficult to obtain an indication which visually simulates the actual position of the aircraft in flight. For example, the AGI-1 master attitude indicator simulates the horizon by a white line on a spherical scale, distinguishing the "sky" (the blue background) from the "ground" (the brown background). At the same time, however, the "sky" is below, and the "ground" is above, the horizon line, making it necessary for

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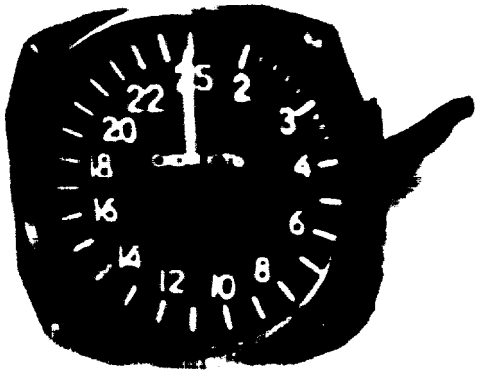

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Figure 64. KUS-2500 speed indicator

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the pilot to reorient himself when shifting from visual flight to instruments. A material deficiency in the AGI-1 master attitude indicator is its property of kicking out (the matching of the external axis of the cardan ring with the axis of the horizon) when the aircraft is doing complicated maneuvers involved in piloting. In addition, the AGI-1 has large post-takeoff and post-turn errors.

These errors, in the AGD-1 master attitude indicator, have been eliminated, or have been reduced to a minimum.

In the AGD-1 the visual indicator for the horizon is a follow-up system which reproduces the bank and pitch angles in accordance with electrical signals provided by the remote gyro transmitter. This has permitted the provision of the most rational, large-scale system of indications with the "ground" and the

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"sky" in their natural positions.

Complex Composition

The AGD-1 master attitude indicator complex contains:

the gyro transmitter;

the horizon indicator (figure 65).

The 27 volt supply for the master attitude indicator comes from the aircraft network, while the alternating current, 36 volts, 400 cycles, three phase, comes from the PT-500Ts converter.

A correction cut-out switch, VK-53RB, is connected to the gyro transmitter in order to cut out the transverse correction when the aircraft is turning.

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The PT-500Ts converter and the VK-53RB correction cut-out switch are not a part of the AGD-1 complex.

AGD-1 Master Attitude Indicator Operating Principles

A kinematic diagram of the transmitter and indicator is given in Figure 66.

The gyro transmitter is a gyroscope with three degrees of freedom and consists of the gyro unit 16 and a cardan ring 20 installed in bearings in the follow-up gimbal 22. The follow-up gimbal, with the help of the fine adjustment motor 14, constantly maintains the external axis of the cardan ring 20 (the axis of rotation) in a position which is perpendicular to the main axis of the gyroscope 19.

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Figure 65. AGD-1 Indicator

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Fine adjustment of the gimbal is made in accordance with a signal from the induction transmitter 13, the armature of which is fixed to the shaft of the gyro unit, while the stator is fixed to the cardan ring. When the external axis of the cardan ring is displaced from the position perpendicular to the main axis of the gyroscope 19, the induction transmitter sends an AC signal to the amplifier input. The signal is amplified and delivered to the type DG-1 motor-generator 14, which, through a reduction, makes the fine adjustment of gimbal 22, while, at the same time, restoring perpendicularity of the external axis of the cardan ring and the main gyroscope axis. At the same time,

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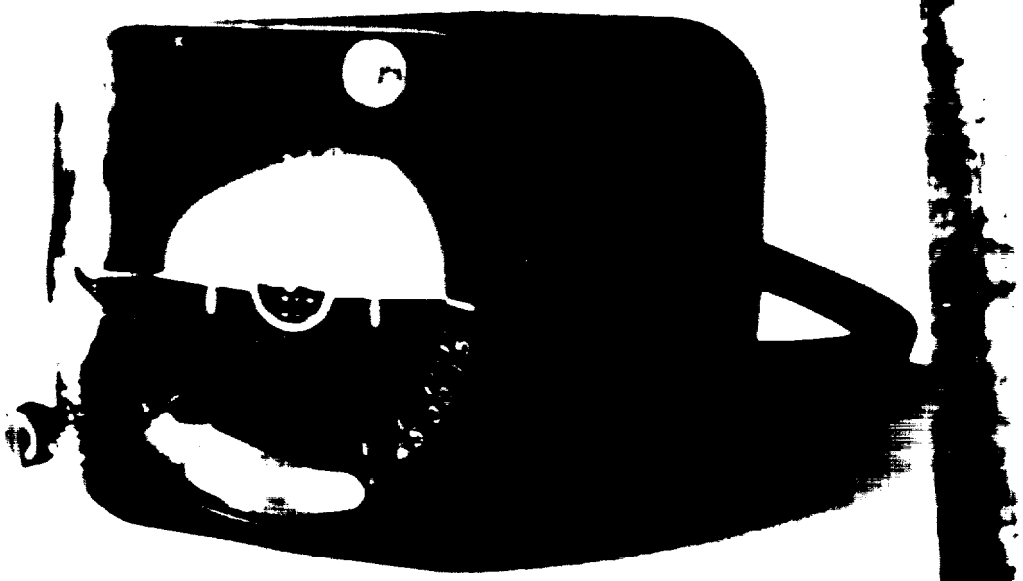

Figure 65. AGD-1 Indicator

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this fine adjustment takes place at a rate known to be greater than the possible rate of change in the banking of the aircraft. As a result, for any aircraft maneuver, the gyroscope rotor axis does not coincide with the cardan ring axis and the gyro transmitter takes on the property of "not kicking out."

In order to damp out oscillations in the gimbal 22 in the cource of making the fine adjustment, a tachosignal from the motor-generator (that is, a voltage which is proportional to the rotation rate of the gimbal) is fed to the amplifier in the form of a negative speed feedback where it is summed with the signal from the induction transmitter. In the event the pitch angle of the aircraft is greater than 90°, and in order to provide for correct movement of the gimbal to make the fine adjustment, the phase of the control signal from the induction transmitter to the motor-generator 14 is switched by the commutator 17. The commutator 17 is located on the external shaft of the cardan ring. Owing to the presence of the commutator, the follow-up gimbal has two operating positions relative to the gyro rotor axis: a main position to which it is adjusted by a remote caging system, and position rotated 180°. Normal tracking of the gyro axis by the gimbal is assured in both positions.

The vertical position of the gyroscope rotor shaft is controlled by a pendulous, liquid corrector (not shown in the diagram) secured to the lower surface of the gyro unit. The corrector acts on two correction motors, the longitudinal correction (21), located on the internal shaft of the cardan ring, and the transverse correction (18), located on the

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external shaft of the cardan ring. Roll and pitch signals are provided by the plane selsyns. The pitch selsyn transmitter (S_T) is located on the external shaft of the cardan ring, while the roll selsyn transmitter (S_K) is located on the gimbal shaft.

When the position of the gimbal is upset the zero positions of the roll and pitch selsyn rotors change, relative to the stators, by 180°. In addition, the direction in which the pitch selsyn rotor turns relative to the stator for changes in pitch changes in the opposite direction. In order to provide a correct position for the horizon indicator when the position of the gimbal is upset, the signals from the gyro transmitter for the roll and pitch selsyns are switched. The switched signal is supplied by the commutator 26 located on the external shaft of the cardan ring.

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Figure 66. Diagram showing kinematic principle of the AGD-1.

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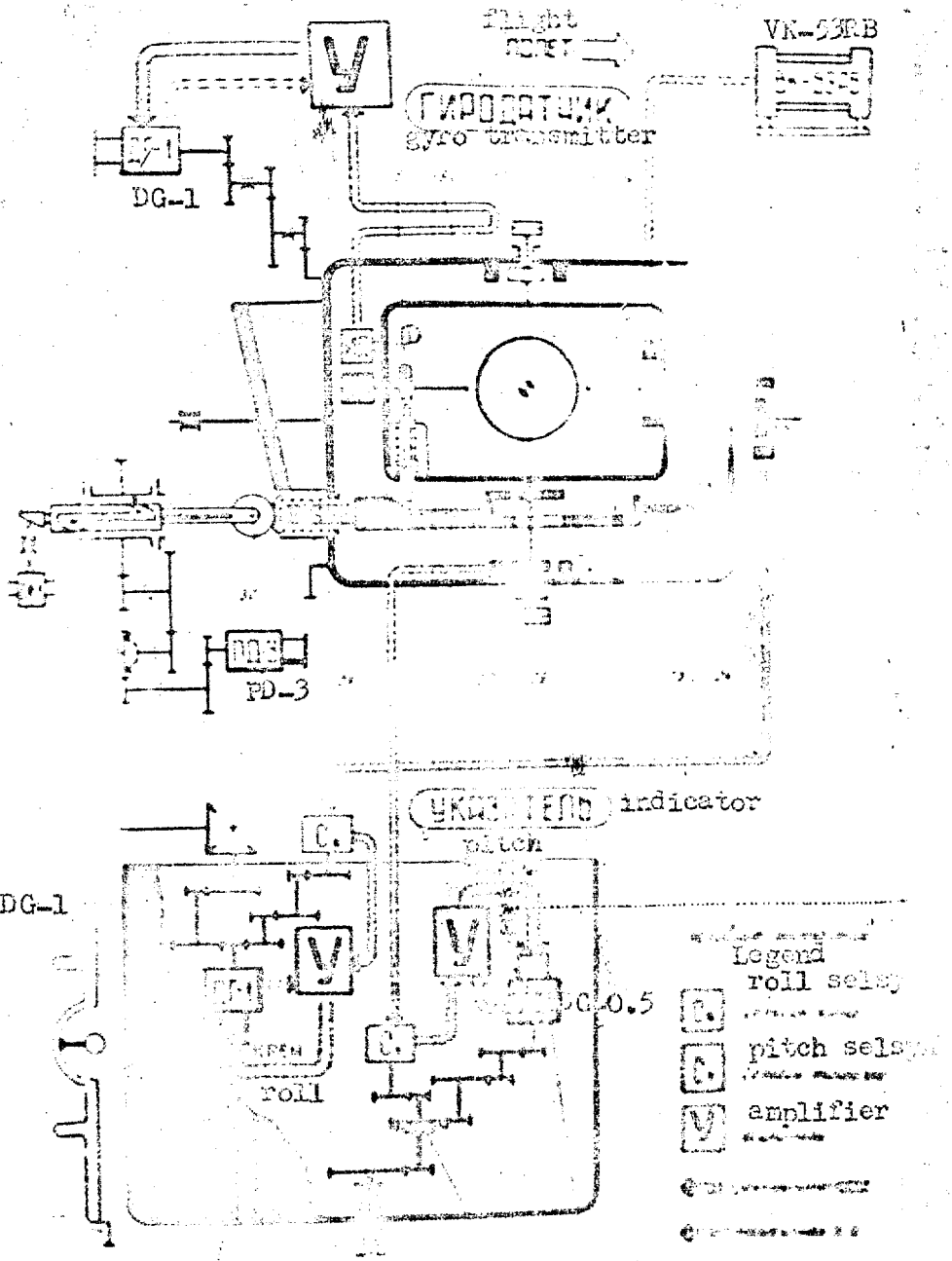

Figure 66. Diagram showing the kinematic principle of the AGB-1.

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Figure 66. Diagram showing kinematic principle of the AGD-1

1 - Pitch motor-generator, DG-0.5

2 - 7 - Friction clutch

3 - Card

4 - Aircraft silhouette

5 - Roll motor-generator, DG-1

6 - PD-3 caging device motor

8 - VK-1 terminal switch

9 - Detent or cam

10 - Caging device coupling rod

11 - Output gear

12 - 15 - 25 - 28 - Detent or cam

13 - Induction transmitter

14 - DG-1 motor-generator for fine adjustment of the follow-up gimbal

16 - Gyro unit

17 - 26 - Commutator

18 - Transverse correction motor (for pitch)

19 - Main shaft of TsGV gyroscope

20 - Cardan ring

21 - Longitudinal correction motor (for roll)

22 - Follow-up gimbal

23 - VK-2 terminal switch

24 - Plunger

27 - Spindle

29 - Return spring

30 - Roller

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Switching of signals for the selsyns is accomplished through the use of special relays in the gyro transmitter and in the horizon indicator.

Cutting out the gyroscope correction has been anticipated in order to increase the accuracy with which roll and pitch are indicated in the course of the evolutions carried out by the aircraft. When the aircraft is turning the transverse correction is cut out by series connected correction switch VK-53RB.

Cutting out the longitudinal corrections when longitudinal accelerations are active (acceleration, take-off, braking) is accomplished by the liquid accelero-meter for longitudinal accelerations, located in the gyroscope of the gyro transmitter.

Caging

The gyro transmitter has an electrical-mechanical caging device to reduce to a minimum the time required to prepare the AGD-1 for operation.

In the course of starting up the caging device operates automatically, and, at the same time, the plane of the follou-up gimbal 22 takes a position parallel to the base of the instrument, while the main shaft of the gyroscope takes up a position which is perpendicular to it. After this caging takes place automatically.

The caging device consists of the following parts (cf. figure 66);

DC motor 6 and reduction gearing and friction clutch 7;

four detents, or cams, 12, 15, 25, 28;

return spring 29;

plunger 24 and spindle 27.

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Caging takes place as follows (providing the gyro unit, the cardan ring and the gimbal are in an arbitrary position).

When a voltage is supplied to the caging motor 6 the motor starts and, through its reduction gearing, turns output gear 11. The bushing of gear 11 has a pin which moves along in a spiral groove in the coupling rod 10 and moves it. The coupling rod of the caging device, 10, can move back and forth without turning in the bushing of the output gear. At the same time that coupling rod 10 is moving, the roller, 30, rolls along the helical line of the detent, 12, and, also at the same time, the tracking frame, 22, is turned around into the vertical position. As further movement of the coupling rod takes place, detent 25 causes the plane of the cardan ring, 20, to be turned into the horizontal position as well. Then, by means of detents 15 and 28, and spindle 27, the axis of gyroscope 19 is brought to a position which is perpendicular to the plane of the cardan ring.

The gyro unit is ready to start.

Complete caging of the instrument takes place after one turn of the output gear. During this period of time the guide pin is displaced the value of one step along the spiral groove in coupling rod 10. At this point it falls into the longitudinal groove and, under the influence of spring 29 and of the spring inside the coupling rod, is tilted forward. At this time the supply to the motor 6 is cut out and an alternating current supply of 36 volts at 400 cycles is provided to the gyro motor and the correction system.

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During the caging process a signal light should burn on the indicator. The

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caging process takes about 15 seconds.

Terminal switches KV-1 and KV-2 ensure automatic, sequential cutting in and cutting out of direct and alternating current voltages for the system which starts up and indicates the master attitude indicator position.

After the gyroscope is started the signals from the roll (S_K) and pitch (S_T) selsyns for the gyro transmitter are fed to the selsyn receiver in the tracking system of the indicator (see figure 66; signals depicted by arrows).

An exterior view of the remote indicator is shown in figure 65. The indicator reproduces the roll and pitch angles of the aircraft, measured by the transmitter.

The horizon indicator consists of two tracking systems, for pitch and roll, which provide for the changing the positions of the movable elements, the indicator card and the aircraft silhouette.

The kinematic schematic of the indicator can be seen on the lower part of figure 66.

The pitch tracking system consists of the selsyn receiver (S_T), which is connected to the selsyn transmitter in the gyro transmitter, the DG-0.5 motor-generator, the reduction, and the amplifier.

The system functions in the following manner. When there is a mismatch between the selsyn receiver and the selsyn transmittter the mismatch signal is fed from the rotor of the selsyn receiver for the indicator to the amplifier.

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The output voltage from the amplifier causes rotation of the DG-0.5 motor-generator, which, through the reduction gearing, transmits the rotation of the card 3 to the rotor of the selsyn receiver, moving it to a position which corresponds to the position of the rotor of the selsyn in the gyro transmitter.

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The tachosignal from the DG-0.5 motor-generator, in the form of negative feedback, is supplied to the amplifier, where it is summed with the selsyn receiver rotor signal. This, at the same times, ensures that oscillations in the pitch tracking system are damped. Thus, the card is always brought to the position corresponding to the rotation angle of the gyro transmitter selsyn; that is, the horizon indicator reproduces the pitch angle.

The enlarged scale for reading the pitch angle over the entire scale range is attained as a result of the various transmitted relationships from the DG-0.5 motor-generator to the card and to the selsyn rotor. A rotation of 1.7° of the card is equivalent to one degree of rotation of the selsyn rotor. A special stop limits the travel of the card in the range ±145° which, on the card scale is ±85°. Maximum speed at which the card settles out is at least 80° per second. It is possible to adjust the position of the horizon for the pitch scale (card) over a range of ±12° by turning the selsyn (S_T) stator with the aid of the alignment rack.

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The rack is located on the port side on the face of the indicator. Also connected with the alignment rack is the alignment index, located on the port side of the face of the indicator.

The roll tracking system consists of elements which are similar to those above and operates in the same manner as does the pitch tracking system. The transmission relationship from the motor-generator 5 (DG-1) to the roll selsyn and the aircraft silhouette is identical. The maximum speed at which the aircraft silhouette settles out is at least 360° per second. The roll indication system has no manual correction.

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All weak signals from the transmitters are fed to the executing and tracking mechanisms through electronic amplifiers.

Electrical Supply Circuit

The supply to the AGD-1 master attitude indicator is direct current at a voltage of +27 volts (from the aircraft network) and alternating current at 36 volts, 400 cycles (from the PT-500Ts converter).

The elements in the switching apparatus, the semi-conductor amplifiers, and the caging apparatus drive are supplied with +27 volts, direct current.

The gyro motor in the central gyro transmitter, the selsyn tracking systems,

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the correction devices, and the semi-conductor amplifiers are supplied with 36 volts, 400 cycles, alternating current.

Figure 67 is the electrical schematic of the supply to the AGD-1.

In order to cut in the master attitude indicator it is necessary to cut in the AZS-5 (sym. 35S) on the starboard console (zone "M") which is inscribed "ARU-FOSh, remote lamp, heater KKO, AGD," while, at the same time, supplying excitation "positive" to the signal for the disconnected position of the AGD-1 across two phases, alternating current.

No.	No. of position in electrical schematic	Designation	Type	Quantity	Location
1	2	3	4	5	6
1	1N	Circuit breaker	AZS-5	1	Starboard console, Zone "K"
2	2N	Converter	PT-500Ts	1	Upper equipment hatch, frames 4-5
3	3N	Indicator	AGD-1	1	Instrument panel, zone "B"

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1	2	3	4	5	6
5	4N	Fuse	IN-50	1	Power unit, starboard side frames 12-13
6	12N	Correction switch	VK-53RB	1	Cockpit, frames 5-7
7	17N	Relay	TKYe-53PD	1	Relay box, upper equipment hatch, frame 4, starboard
8	19N	Relay	TKYe-21PD	1	ditto

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9	20N	Fuse	SP-35	1	Upper equipment hatch, starboard side, frames 4-5
9	21N	Fuse	SP-35	1	ditto
10	24N	TsGV gyro transmitter	AGD-1	1	Upper equipment hatch, frames 5-6
11	35S	Circuit breaker	AZS-5	1	Starboard console, zone "M"

AZS-5, sym 1N, on the starboard console (zone "K") is then cut in, whereupon the caging process begins. After caging, the winding of relay symbol 19N is energized and its closed contacts 2-3 provide the path for negative to start the PT-500Ts converter. The converter is started.

Alternating current, 36 volts, three phase, is taken from the generator winding. This flows through fuses symbols 20N and 21N (phases I and II) and directly (phase III) to supply the gyro motor and the tracking systems in the master attitude indicator.

In the event the two-phase AC supply to the AGD-1 indicator is interrupted the "positive" signal light will light up, fed, in this case, from the AZS-5 symbol 35S.

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Figure 67. Schematic of the location of the AGD-1 in the aircraft and the electrical supply schematic

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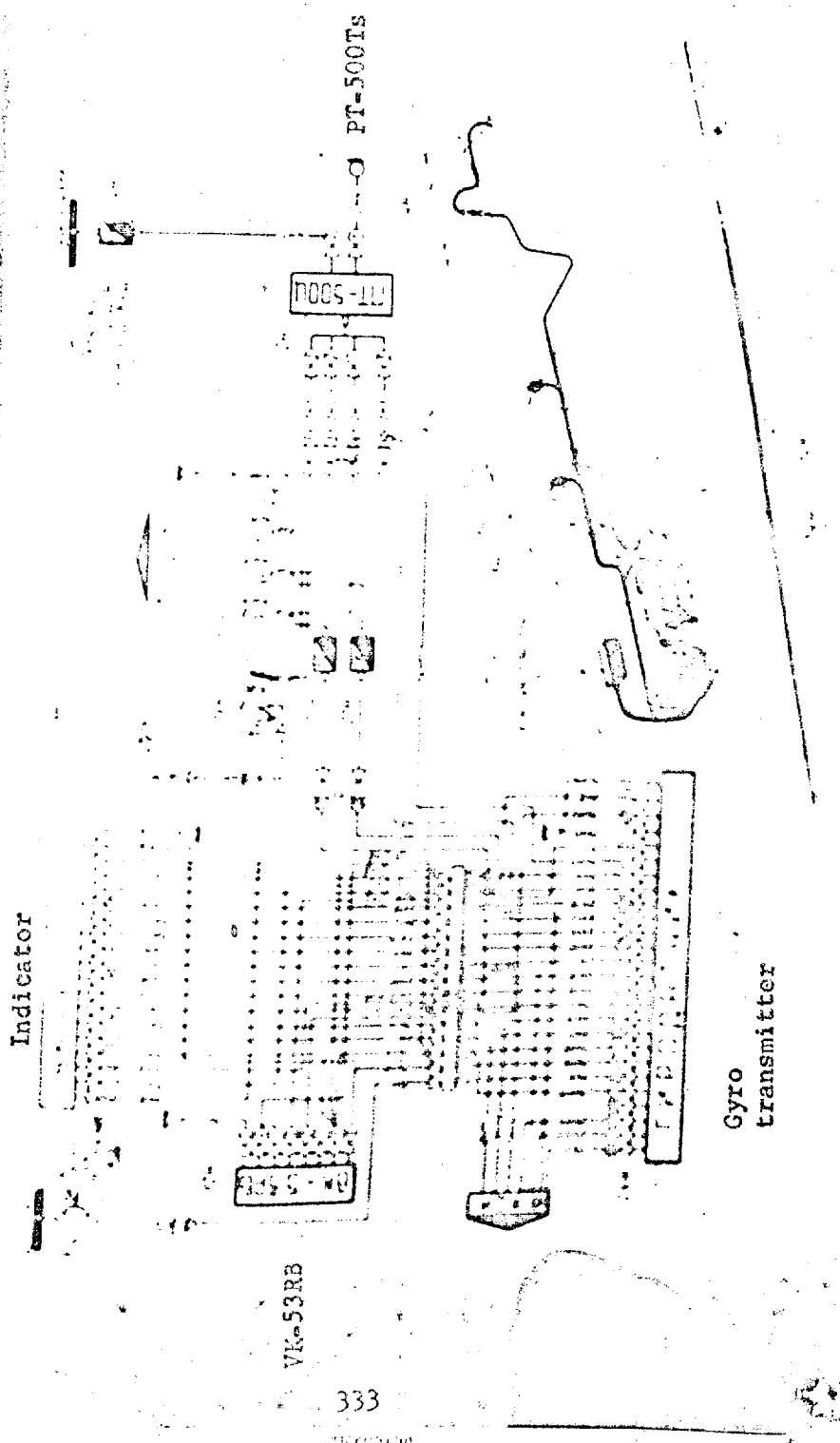

Figure 67. Schematic of the location of the AGD-1 in the aircraft and the electrical supply schematic

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Installation of the Master Attitude Indicator in the Aircraft (Figure 67)

The AGD-1 indicator is installed on the shock-mounted section of the instrument panel (zone "B") right in front of the pilot. The indicator is secured to the instrument panel by three bolts which fit into the instrument flange and are held by three self-locking nuts. The plane of the indicator face is set perpendicular to the longitudinal axis of the aircraft. Panel design is such that it is possible to adjust the indicator by setting the mark for the roll scope (krenoskop) in the middle position.

The gyro transmitter is installed in the forward equipment compartment, between frames 5 and 6.

The gyro transmitter is mounted in a specially shock-mounted frame which permits making adjustments in the vertical. In turn, the special frame is secured to a bracket which is part of the aircraft so that it is possible to make adjustments in the horizontal plane as well.

There is, on the gyro transmitter housing, an arrow which indicates the direction of flight. Accurate positioning, relative to the longitudinal axis of the aircraft, is accomplished by matching the scribe mark on the special frame with that on the bracket which is part of the aircraft construction. Accurate installation of the gyro transmitter in the horizontal plane is accomplished through the use of a liquid level, which can be seen through a window in the upper part of the housing.

Inaccuracy in installing the gyro transmitter relative to the longitudinal axis will result in an additional error in roll indication. This error can be determined from the following relationship:

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$$tg\,\Delta\gamma = tg\,\gamma \cdot \sin\delta$$

where:

δ is the error in the installation of the gyro transmitter, relative to the longitudinal axis in azimuth;

ν is the pitch angle;

$\Delta\gamma$ is the additional roll error.

Basic technical data for the master attitude indicator AGD-1

1. Readiness of the complex for operation after supply is cut in (with the aircraft's angular attitude in roll and pitch directions on the ground not more than $\pm 4^\circ$):

for temperatures from +50 to -30°C - 1 minute;

for temperatures from -30 to -60°C - 1.5 minutes.

2. Duration of gyro transmitter caging cycle (cage - uncage) - not more than 15 seconds.

3. Operating angles, within the limits of which correct indications are given:

in roll - 360°

in pitch - 360°

with the exceptions of the zone 85°-95° for dive and climb.

4. Accuracy of the gyroscope in the gyro transmitter holding its vertical with insertion of correction on immovable stand:

in roll $\pm$ 0.25°

in pitch $\pm$ 0.2°.

5. Errors in roll angle indications after completing 360° turn - not more than $\pm 8^\circ$ (individual, sharply defined maximums of up to 5 or 6 degrees are

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feasible).

Errors in roll and pitch angle indications after completion of any complicated piloting maneuver - not more than $\pm 5^{\circ}$.

6. Correction rate for gyro scope of gyro transmitter:

transverse: 2 to 8 degrees/minute;

longitudinal: 1 to 3 degrees/minute.

7. Angular turning rate at which the transverse correction for the gyro transmitter cuts out as a result of signal from the VK-53RS correction switch - 0.1 to 0.3 degrees/second.

8. Horizontal component of the longitudinal acceleration of the aircraft for which the longitudinal correction is, for all practical purposes, cut out - 1.67 meters/sec^2.

9. Successive errors not more than 3°.

10. Maximum settling rate for gyro transmitter follow - up signal - not less than 360 degrees/second.

11. Error in transmission of roll and pitch angles to horizon indicator:

from 0° - $\pm 1^{\circ}$

to $\pm 30^{\circ}$ - $\pm 1.5^{\circ}$

(over) $\pm 30^{\circ}$ - $\pm 2.5^{\circ}$.

12. Sensitivity of horizon indicator to changes in roll and pitch angle no worse than 0.3°.

13. Current requirements:

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phases 1 and 3 - not more than 1.6 amperes;

phase 2 - not more than 1.2 amperes;

(b) from DC source (aircraft's +27 volts) - not more than 0.75 ampere.

NOTE: When the correction switch is cut in (VK-53RB) AC requirements are increased by 0.4 ampere in the phase.

14. Temperature operating interval - from +50° to -60°C.

15. Altitude - 20,000 meters.

16. Weights of AGD-1 aggregates:

gyro transmitter - 7 kilograms;

horizon indicator - 2.6 kilograms;

correction switch - 2.6 kilograms;

PT-125Ts converter - 5.2 kilograms.

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C. KSI Fighter Plane Course System

The KSI course system serves to determine the aircraft's course, landing course angles, and radio station bearings.

As distinguished from previously developed, magnetic compass, course systems, the KSI:

provides necessary accuracy in determining course (not less than $\pm 2^{\circ}$) and the mode for horizontal, direct flight;

has no cardan errors occurring as a result of aircraft roll;

provides a high degree of accuracy when the aircraft is engaged in irregular flight.

Providing the high degree of accuracy for determining courses when the fligh pattern is an irregular one, and when the roll angles are large, results from the

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use, in the KSI course system, of a highly stable gyroscope (type RPK-B2) and stabilization of the axes of the external cardan ring of the gyroscope in the vertical.

So long as the flight characteristics of the fighter are those of irregular flight, it is impossible to use any type of course corrector for this type of flight (because of the large corrector errors).

In the case the aircraft's course is taken from the free gyroscope.

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Thus, the basic operating mode for the course system is that of a directional gyro, while the magnetic correction mode is that of an auxiliary one, used to correct the former on the ground (prior to take-off), or in direct, horizontal flight.

Composition

The composition of the complex includes:

1 -	the gyroscope aggregate	GA-2;
2 -	the matching mechanism	MS-1;
3 -	the induction transmitter	ID-2;
4 -	the correction mechanism	KM-3
5 -	the control panel	PU-3;
6 -	the indicator	UGR-4U;
7 -	the amplifier	U-12;
8 -	the amplifier	Ú-18;
9 -	the matching pushbutton	5KS;
10 -	the relay block	BR-4.

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NOTE:

(1) To determine course angles and radio station bearings, signals from the ARK-10 radio compass, fed to the UGR-4U indicator, are used.

(2) To provide for operation of the course system in the aircraft, signals from the STsGV central vertical gyro (AGD-1 gyro transmitter) are used.

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Structural Schematic
(Fig. 68)

The key unit in the KSI course system is the GA-2 gyroscope, which is a course gyro with three degrees of freedom and which has two additional frames for stabilizing the axis of the external gyroscope frame in the vertical. Settling out of the additional frames is brought about with the aid of the roll ψ and pitch ν signals supplied by the TsGV (AGD-1 transmitter) central vertical gyro.

Aircraft course signals are transmitted to the UGR-4U indicator directly by the remote selsyn transmitters, which function as three transformers, from the GA-2 gyro aggregate by way of the MS-1 matching mechanism.

The GA-2 gyroscope has no azimuth correction. The main axis of the gyro assumes an arbitrary position in azimuth with respect to the magnetic meridian.

Course signals, provided by the gyro aggregate, are corrected by turning the differential selsyn rotor in the matching mechanism.

The magnetic course corrector is the induction transmitter ID with KM-3 correction mechanism. The principle of operation of the magnetic corrector is based on the strong, inductive sensitivity of the element installed in the ID for determining the position of the transmitter relative to the magnetic meridian; that is, to determine the aircraft's magnetic course. The sensitive element in

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The transmitter is the magnetic probe, which has a core made of permalloy rods.

The correction is made by pushing the matching button on the "KSI" instrument panel, whereupon the signal from the induction transmitter and correction mechanism is fed to the MS-1 matching mechanism. At the same time the differential selsyn rotor is turned to the corresponding angle and indications for the UGR-4U indicator are matched with the indications from the GA-2 gyro transmitter.

When the button is released the correction is cut out and further operation of the UGR-4U indicator takes place in the directional gyro mode.

The time to make the match, for a maximum mismatch of induction transmitter positions and indicator reading, is not in excess of 23 seconds. It is not recommended that the button be pushed in flight if the duration of the flight is not in excess of 30 minutes.

Compensation for the obvious departure of the gyroscope from the earth's daily rotation is accomplished by feeding a signal from a special potentiometer, ZSh, (latitude controller), which is located on the PU-3 control panel. This signal, after amplification by the U-12 amplifier, is fed to the MS-1 matching mechanism motor which, through a reduction, rotates the selsyn rotor with an angular velocity corresponding to the earth's rotation for the given latitude.

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Figure 68. KSI Course System Block Schematic

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The latitude correction switch on the PU-3 control panel should be set to one of the positions, "North" or "South," according to which hemisphere the flight is in.

The BR-4 relay block is designed to ensure the operation of the course sys-

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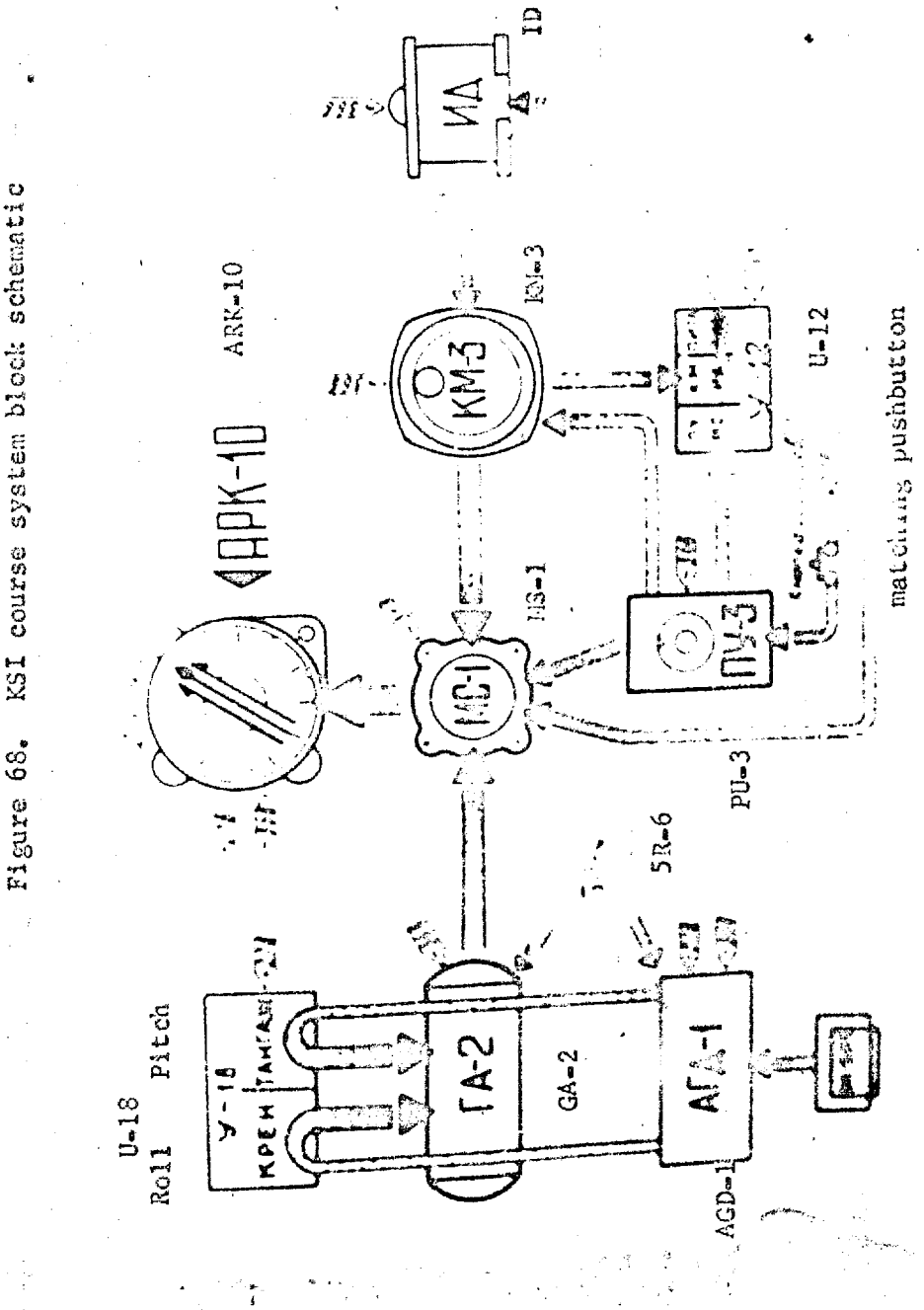

Figure 68. KSI course system block schematic

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tem when the aircraft is carrying out advanced flying maneuvers and in eliminating errors in course indications equal to 180° after completing a Nesterov halp-loop.

Location of KSI Blocks in the Aircraft

The locations of blocks in the KSI system in the aircraft are as follows (see figure 69):

1. in the forward equipment compartment (in the frame 3A zone):

the GA-2 gyro aggregate;

the MS-1 matching mechanism;

the PU-3 control panel with latitude corrector;

the PT-500Ts converter (not included in the complex);

the BR-4 relay block.

2. in the cockpit:

behind the instrument panel:

the U-18 amplifier;

the U-12 amplifier;

on the instrument panel:

the UGR-4U indicator;

the 5KS matching pushbutton;

on the forward electrical switchboard for the starboard console:

the "KSI" AZS-5 circuit breaker (not included in the complex)

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Figure 69. Schematic location of KSI in the aircraft
1 - MS-1 matching mechanism; 2 - GA-2 gyro aggregate; 3 - PU-3 control panel 4 - PT-500Ts converter; 5 - U-12 amplifier; 6 - U-18 amplifier; 7 - UGR-4U indicator; 8 - correction mechanism; 9 - ID induction transmitter; 10 - 5MS matching pushbutton; 11 - BR-4 relay block

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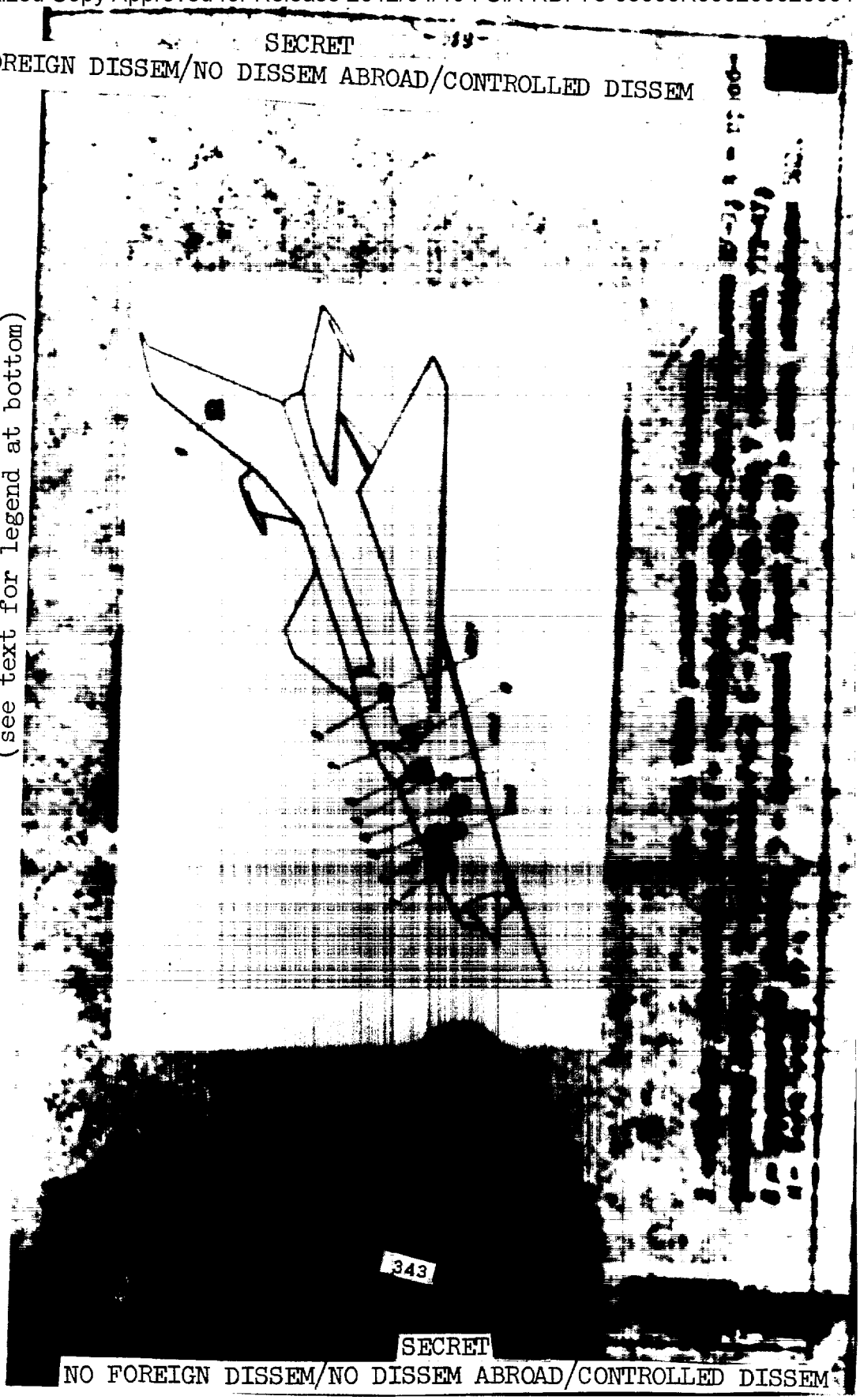

Figure 69. Schematic location of KSI in the aircraft (see text for legend at bottom)

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2. The KM-3 correction mechanism is installed in the frame zone, to starboard and upward with respect to the line of flight.

3. The ID induction transmitter is installed in the tail fin in the rib 10 zone.

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KSI Electrical Supply

Supply for the KSI system comes from the aircraft network in the form of +27 volts DC, and from the PT-500Ts converter in the form of 36 volts, 400 cycles, AC.

The electrical schematic for the supply circuits is shown in figure 70.

When the AZS-5, symbol 10N, located on the starboard panel, is cut in 27 volts is supplied from the aircraft network to:

relay symbol 16N;

5KS matching pushbutton, symbol 15N;

U-18 amplifier, symbol 18N;

UGR-4U indicator, symbol 9N.

After the PT-500Ts, symbol 2N, is started alternating current at 36 volts and 400 cycles, three phase, is taken from the converter and fed to the following blocks (phases 1 and 2 through fuses SP-5, symbols 22N and 27N, and the closed contacts of the relay, symbol 16N; phase 3 directly):

GA-2 gyro aggregate;

UGR-4U indicator;

MS-1 matching mechanism;

PU-3 control panel;

KM-3 correction mechanism;

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ID induction transmitter;

U-12 amplifier.

The +27 volts DC from the aircraft network is used to supply the switching apparatus in the semiconductor amplifiers.

The 36 volts, 400 cycles, 3-phase AC supplies the GA-2 gyroscope motor, the selsyns in the tracking system, the electric motors in the correction systems, and the induction transmitter (see the block schematic in figure 69).

No.	No. of position in electrical schematic	Designation	Type	Quantity	Location
1	2	3	4	5	6
1	2N	Converter	PT-500Ts	1	Upper equipment hatch, frames 4 and 5
2	4N	Fuse "PT-500Ts converter for KSI, AGD, VRD	IP-50	1	Power unit, starboard side, frames 12-13
3	7N	Matching mechanism	MS-1	1	Upper equipment hatch, to starboard, frames 3-4
4	5N	Gyroscope aggregate	GA-2	1	Upper equipment hatch, frames 3-4
5	9N	Indicator	UGR-4U	1	Instrument panel, zone "B"
6	10N	Circuit breaker	AZS-5	1	Starboard console, zone "K"
7	11N	Correction mechanism	KM-3	1	Cockpit, to starboard, frames 10-11
8	13N	Amplifier	U-12	1	Cockpit, frames 6-7
9	14N	Induction transmitter	ID	1	Tail fin

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1	2	3	4	5	6
10	15N	Matching pushbutton	5KS	1	Instrument panel, zone "g"
11	16N	Relay	TKYe-53PD	1	Relay box, upper equipment hatch, frame 4, to starboard
12	18N	Amplifier	U-18	1	Cockpit, to port, frames 6-7
13	22N	Fuse	SP-5	1	Upper equipment hatch, starboard side, frames 4-5
14	23N	Fuse	SP-5	1	[illegible]
15	25N	Control panel	PU-3	1	Upper equipment hatch, port side, frames 3-4
16	30N	Relay block	BR-4	1	Upper equipment hatch

Figure 70. Electrical schematic

Basic Technical Data for the KSI System

1.	Readiness for operation after supply is cut in	3 minutes.
2.	Error in determining magnetic course when flight is direct and horizontal, not more than	$\pm 2^{\circ}$
3.	Additional error after 30 minutes of operation in directional gyro mode	$\pm 2^{\circ}$
4.	Error from remote transmission of course angle from radio compass:	
	zero marking on scale, not more than	$\pm 1^{\circ}$
	other markings, not more than	$\pm 2.5^{\circ}$
5.	Operating angles for roll and pitch	360°

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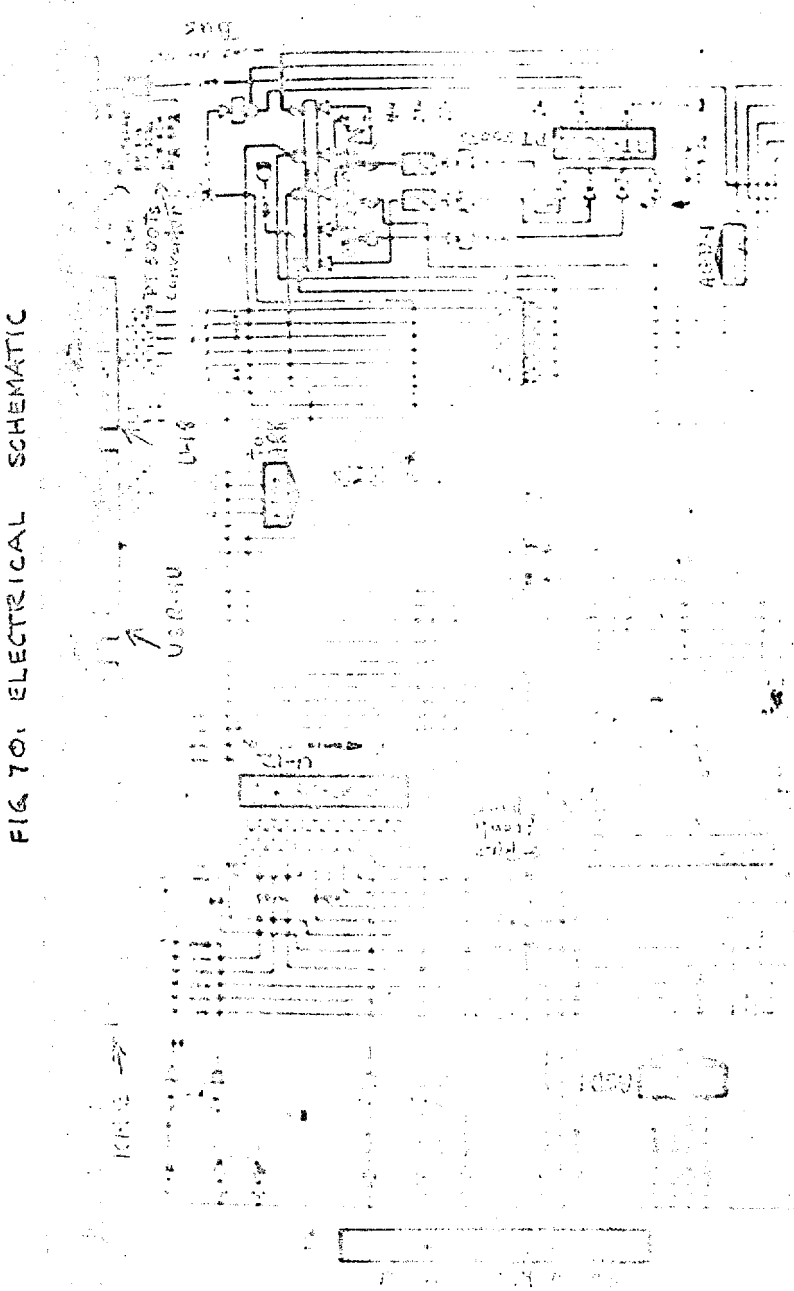

FIG 70. ELECTRICAL SCHEMATIC

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NOTE: There is, for pitch angles of 50±5° and 270±5°, a zone of indeterminate positions along the course which is fixed by the characteristics of the central vertical gyro TsGV (AGD-1 transmitter).

6. The course system operates without fail even when the aggregates have been idle for long periods of time in outside temperatures ranging from 50° to -60°C.

7. Altitude	28,000 meters
8. Supply:	
direct current, volts	+27 ± 10%
alternating current, volts	36 ± 5%
" " frequency, cycles per second	400 ± 2%

9. Power requirements when running steady	
direct current, watts	40
alternating current, volt-amperes	100
NOTE: Starting current:	
direct current, amperes	1.8
alternating current, amperes	9

10. The start system aggregates withstand a landing overload with an acceleration of 4 g.

9. VD-28 Dual-Needle Altimeter

The VD-28 altimeter (figure 71) serves to fix relative altitudes for aircraft flight from 0 to 28 kilometers above the flight area, the landing site, or above other points, the barometric pressures for which are known.

The instrument has two dials. The outer scale, or dial, has a range of indications from 0 to 1,000 meters, with divisions every 10 meters, and a large

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needle for marking the indications. The inner dial has a range of indications from 0 to 28 kilometers in divisions of one kilometer each. A small needle marks the indications on this scale.

The small needle moves one division for every rotation of the large needle; that is, the small needle moves one kilometer. The instrument has a dial setting knob and rack arrangement to make corrections in accordance with outside pressure

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in flight, or when setting the large needle to "0" before [illegible] (the small needle should be on "0").

Figure 71. VD-28 Altimeter

E. EUP-53 Electrical Turn Indicator

The EUP-53 turn indicator, with slip indicator, serves to indicate the deviation of the aircraft from straight-line flight (to port or starboard), as well as correct execution of turns of the aircraft relative to the vertical axis with a transverse roll of up to 45° at a flight speed of 500 kilometers per hour. Figure 72.

The joint operation of the ball and needle makes it possible for the pilot to properly bank the aircraft without skidding when weather conditions are good, as well as when they are not.

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The sensitive element in the turn indicator is a gyroscope with two degrees of freedom.

Supply for the gyro motor comes from the aircraft's direct current network. The electrical schematic is shown in figure 73.

When the AZS-5 (sym. 34K) on the port console switchboard is cut in +27 volts

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Figure 71. VD-28 Altimeter

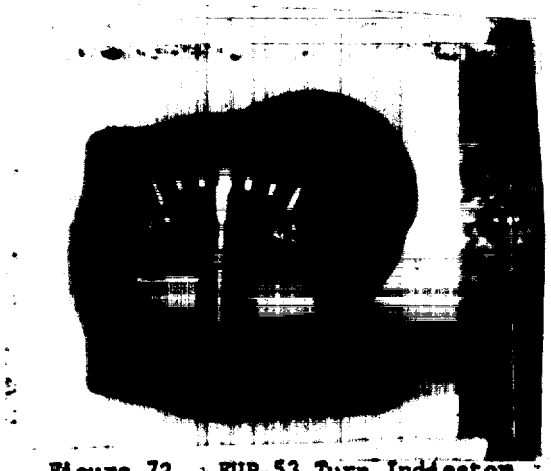

Figure 72. EUP-53 Turn Indicator

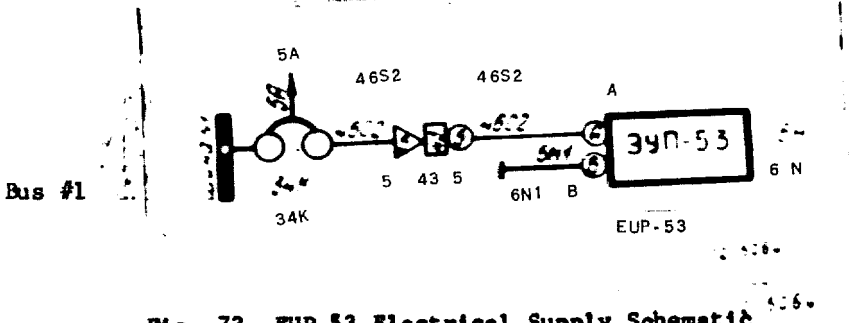

Fig. 73. EUP-53 Electrical Supply Schematic

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from bus number 1 is supplied to terminal "A" of the EUP-53 (sym. 6N), whereupon the gyro motor starts up.

Figure 72. EUP-53 Turn Indicator

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Figure 73. EUP-53 Electrical Supply Schematic

No.	No. of position in electrical schematic	Designation	Type	Quantity	Location
1	6N	Electrical turn indicator	EUP-53	1	Instrument panel
2	34K	Circuit breaker	AZS-5	1	Electrical switchboard, port console

F. Aviation Clocks AChKh

The aircraft's aviation chronometric clocks, AChKh, equipped with electrical heaters (figure 74) provide accurate time readings. When the clock springs are

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fully wound the clocks will run continuously for 6 days. However, for normal operation it is recommended that they be wound once every 5 days. The supply to the heater element is shown in figure 75. When the AZS-20 (sym. 7T) "PVD, clocks," on the instrument panel is cut in +27 volts from bus number 1 is supplied to the heater element (sym. 8T) for the clocks.

Figure 74. AChKh Clocks

Figure 75. AChKh heater electrical schematic

No.	No. of position in electrical schematic	Designation	Type	Quantity	Location
1	7T	Circuit breaker	AZS-5	1	Instrument panel
2	87	Clock heater element			AChKh

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G. VAR-300 Variometer

(Fig. 76)

The VAR-300 variometer serves to measure the vertical climb or dive rate. Knowing the vertical climb or dive rate of the aircraft, the pilot can determine the time needed to select a given altitude, or to plan for a given vertical rate. In horizontal flight the instrument needle is on zero. Deflection of the needle upward from zero indicates the aircraft is climbing, while a downward deflection shows the aircraft is descending. Consequently, the variometer can be used as a horizontal flight indicator as well. The scale on the instrument has been computed to measure changes in the vertical rate from 0 to 300 meters per second. The value of a division, up to 20 meters per second, is one meter per second; above 20 meters per second, the value per division is 20 meters per second.

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Figure 76. VAR-300 Variometer

Figure 77. M-2.5 "M" Number Indicator

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H. M Number Indicator

(Fig. 77)

The M2.5 meter serves to measure the relationship of the true air speed of flight to the rate of propagation of sound (at a given altitude) for aircraft flight altitudes from 0 to 25 kilometers.

$$M = V/a$$

where:

V is the speed of flight of the aircraft in meters per second;

a is the speed of sound in meters per second.

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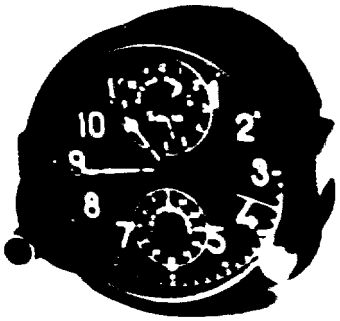

Fig. 74. AChKh Clocks

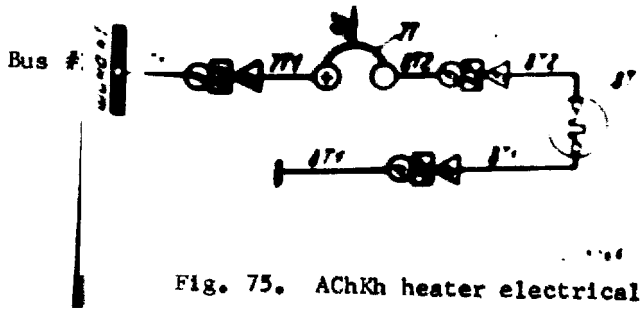

Fig. 75. AChKh heater electrical schematic

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Fig. 76. VAR-300 Variometer

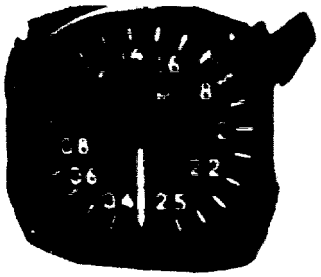

Fig. 77. M-2.5 "M" Number Indicator

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The meter scale has been graduated in accordance with the values of true air speed as related to the speed of sound from 0.4 to 2.5, with the value of each division equal to 0.02 Mach.

I. UV-57 Indicator

The RV-UM radio altimeter indicator serves to determine true flight altitude above the ground surface within a range from 0 to 600 meters.

Flight altitude is read directly off the indicator dial in meters. Each scale division is equal to 50 meters. A potentiometer knob, used to adjust the radio altimeter by "zero set" and "calibration," is brought out on the face of the indicator.

A more detailed description of this particular instrument can be found in Chapter II, "Radio Equipment," of this report.

J. ARU-3V Arm Position Indicator

The type ARU-3V aggregate serves to change automatically, in accordance with a special non-linear law, the transmission ratio from the aircraft control stick to the stabilizer and, simultaneously, to the spring load mechanism.

The adjustment law carried out by the ARU-3V automatically is a function of the velocity head and the altitude at which the aircraft is flying and is determined by the aerodynamics of the aircraft and the physical capabilities of the pilot.

This aggregate provides for a comparatively identical type of piloting technique at various speeds and altitudes. This is achieved by increasing the load on stick and increasing its travel to the degree of deviation of the stabilizer with increase in instrument speed and reduction in flight altitude and, correspondingly, reducing the load and reducing the travel of the stick by the

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[illegible] degree of deviation of the stabilizer with decreased instrument speed and increase in flight altitude (Fig. 78).

In the altitude range from H = 4500 meters to H = 10000 meters, the aggregate functions on the basis of the velocity head as well as the flight altitude.

At altitudes less than 4500 meters the aggregate operates only as a function of the velocity head; that is, for instrument speeds of over 1000 kilometers per hour the needle should be in the starboard stop - the small arm of the ARU and for instrument speeds of less than 500 kilometers per hour the needle should be in the port stop - the large arm of the ARU.

At altitudes of [illegible] meters and higher the aggregate retains constant values for the transmission ratios - the large arm is not dependent upon changes in the velocity head and flight altitude. At velocity heads corresponding to take off, landing and circular flights in the airfield vicinity, the automatic device is in the take off and landing position and the needle should be in the port stop, corresponding to the large arm of the ARU actuating mechanism.

[illegible]

Figure 78. Diagram of the Kinematic Principle of the ARU-3V Automatic Device

[illegible]

The kinematic principle of the automatic device, the arm position indicator, and the adjustment law, are indicated in figure 78.

The ARU-3V operates automatically, reproducing the dynamic and static pressures from the DUAS-8M receiver and intervention on the part of the pilot is not, for normal operation, required. In the event of a breakdown in the control block

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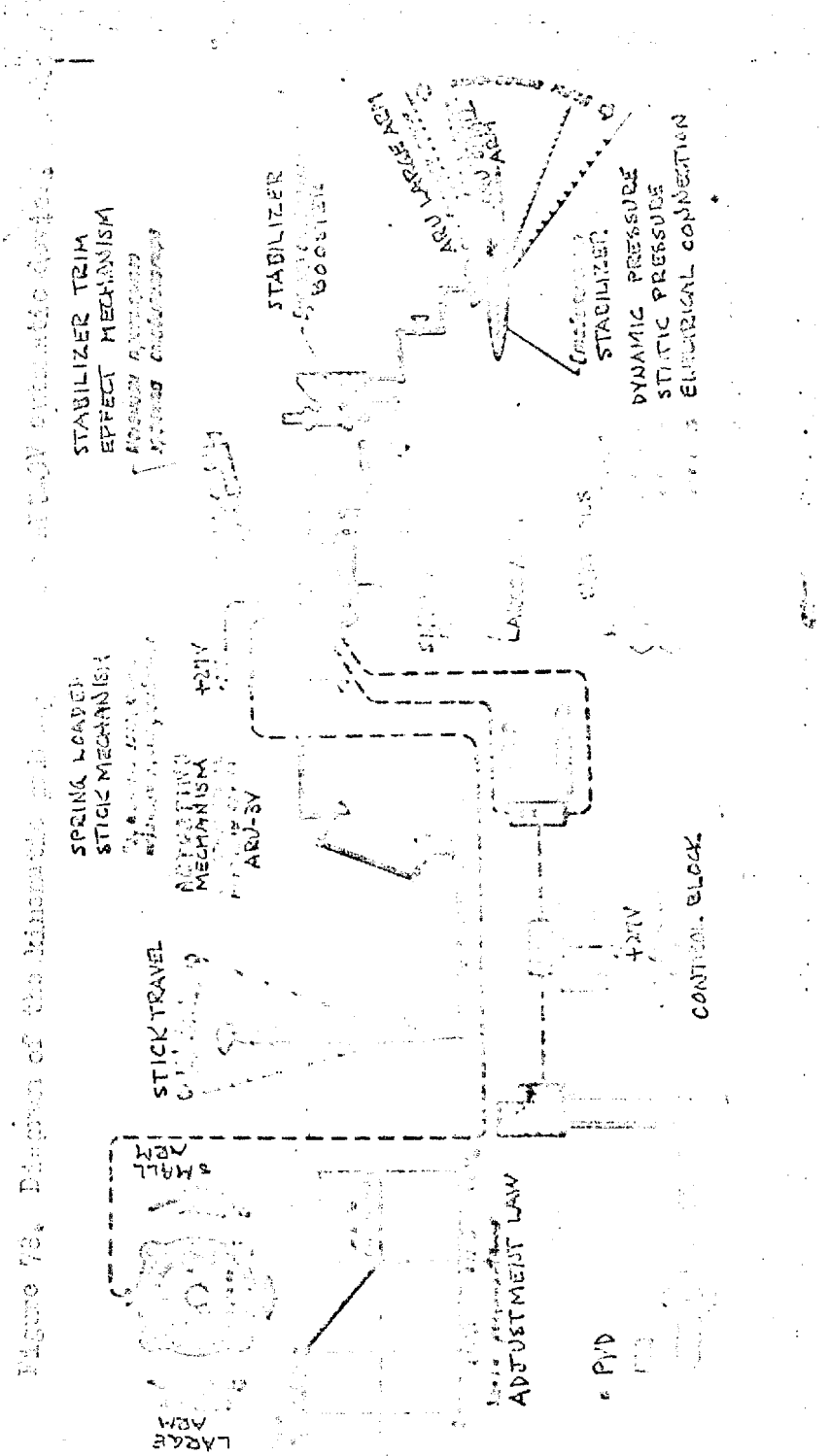

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the pilot can control the actuating mechanism in the ARU by hand by cutting in directly the electric motor drive for the actuating shaft of the mechanism.

Control of the electrical mechanism is carried out by two transfer switches, located on the port console (zone "Z") and inscribed : "High Speed" and "Low Speed," "Automatic" and "Manual," "ARU."

When in manual control the second of the transfer switches should be in the "Manual" position.

Operation of the actuating mechanism is monitored by a signal light on the 1-4 takeoff-landing position for the aggregate "stabilizer landing" (large arm) and by an indicator which has a scale graduated in kilometers per hour and in kilometers of altitude which is, in fact, operated by the actuating shaft of the mechanism (cf. figure 79). The arm position indicator is an ordinary voltmeter sealed in speed and altitude units.

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Figure 79. ARU-3V Arm Position Indicator For Automatic Device

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In actual operating conditions the indications shown on the arm position indicator and on the flight instruments for speed and altitude can be somewhat out of coincidence because of the deviations in atmospheric conditions from standard values, as well as because of fluctuations in the supply voltage from the rated value of 27±0.5 volts to 27± 10% volts.

It should be borne in mind that the position indicator - the indicator for operation of the automatic device - serves to, in general, acquaint the pilot with the fact that the automatic device is functioning satisfactorily.

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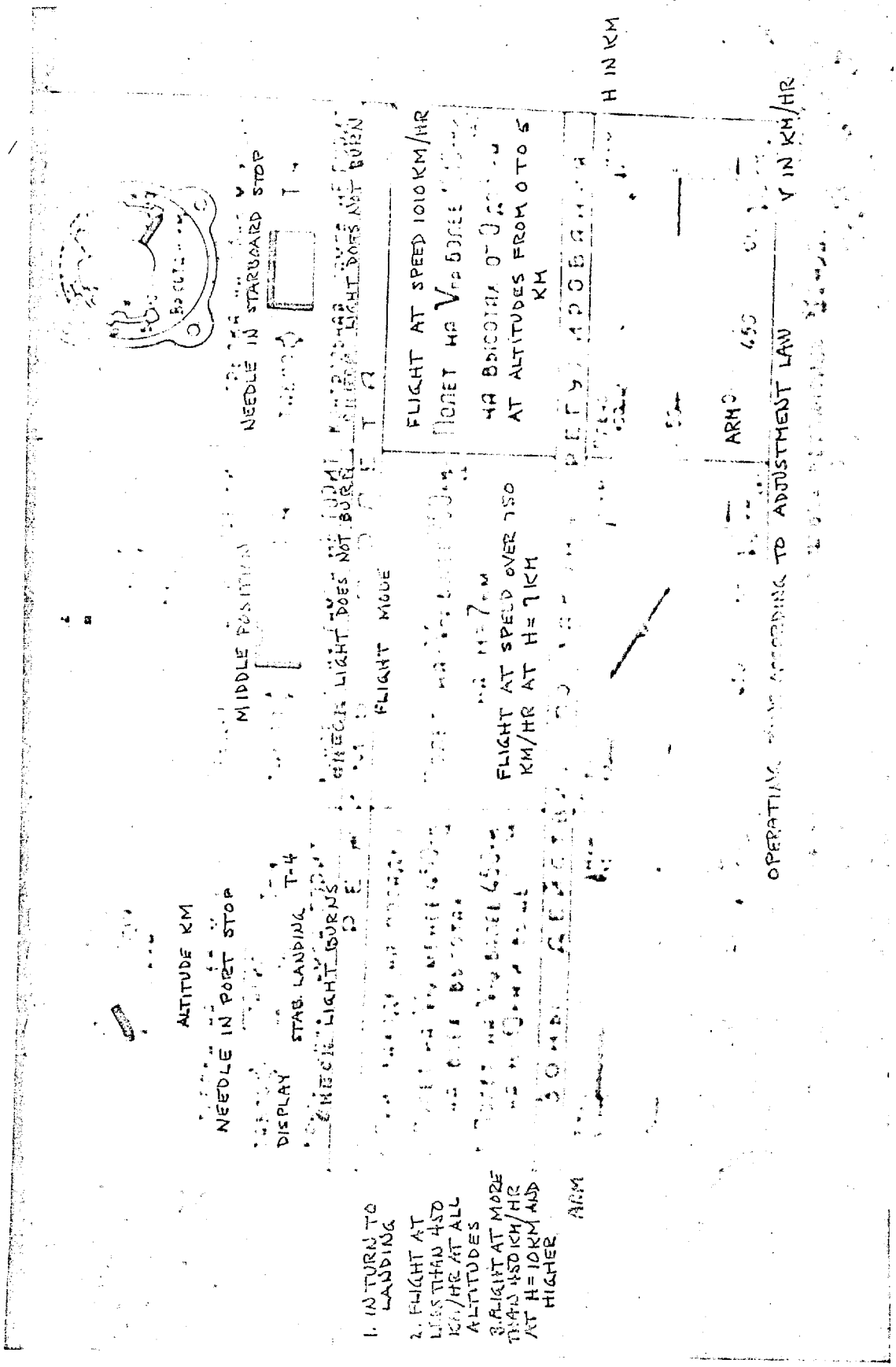

Figure 79. ANU-3V Arm Position Indicator For Automatic Device

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The AM-10 accelerometer (fig. 80) serves to determine the amount of overload acting on the aircraft perpendicular to the plane of the wings when the aircraft is carrying out the flying maneuvers required in the air as well as during other types of movements with velocities involved.

An overload occurs when tensions in the structure have increased somewhat as compared with those which would occur in horizontal flight, when there is only the force of gravity acting. The meter scale is graduated over a range from -4d (d = dyne) to +10d, with each division equal to 0.5 d. The meter has two needles, one, the main needle, used to read the overload, and the other to set maximum overloads.

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There is a knob on the face of the meter which, when pressed, will return the indicator needle to the original position.

Figure 80. AM-10 Accelerometer

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4. Aneroid and diaphragm instrument system

The aneroid and diaphragm instrument system in the aircraft supplies the aneroid instruments with absolute and static pressures.

The system is supplied from the DUAS-8M air pressure receiver installed on a special spar which extends out into an undisturbed flow of air. The spar is installed on a pylon, underneath, in the nose section of the fuselage. When the aircraft is on the ground the spar can be folded upwards to prevent breakage by service personnel.

Some of the instruments, such as the speed indicator, the resolver block for the automatic device in the [illegible]-3V, the Mach meter, the DVS-5, the K2-717,

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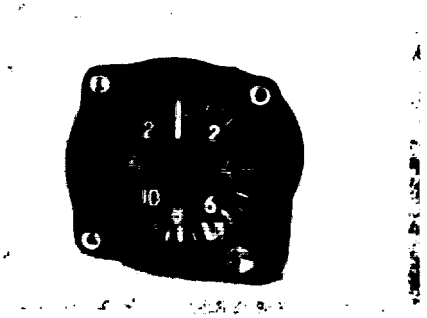

Fig. 80. AM-10 Accelerometer

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and the transmitter in the cone control system receive both types of air pressure, while others of the instruments, such as the variometer, altimeter, altitude and pressure drop indicator, the automatic device for introducing altitude in the ASP-5N sight, the ARD-57 pressure regulator, the VRD-2 and the VS-14500 are supplied with static pressure only.

The principle schematic, as well as the installation diagram, for the system is shown in figure 81.

In the event the main air pressure receiver (1) breaks down there is an emergency receiver, TP-156M, installed on the starboard side of the fuselage, upper, near frame number 3, which supplies the instruments with dynamic pressure.

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Figure 81. Aneroid-Diaphragm Instrument Supply System

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Figure 81. Aneroid-Diaphragm Instrument Supply System

1. DUAS-8M receiver
2. Spar
3. TP-156M receiver
4. VRD-2 permissible range computer (SRD complex)
5. DVS-5 air speed transmitter (SRD complex)
6. Block Number 6 (ASP complex)
7. Condensate trap in the TP-156M main line
8. MR-1.5 and MR-1.9 transmitters
9. Mach number indicator
10. Variometer
11. Speed indicator
12. Valve 623700M for switching dynamic pressure from the main receiver, DUAS-8M,

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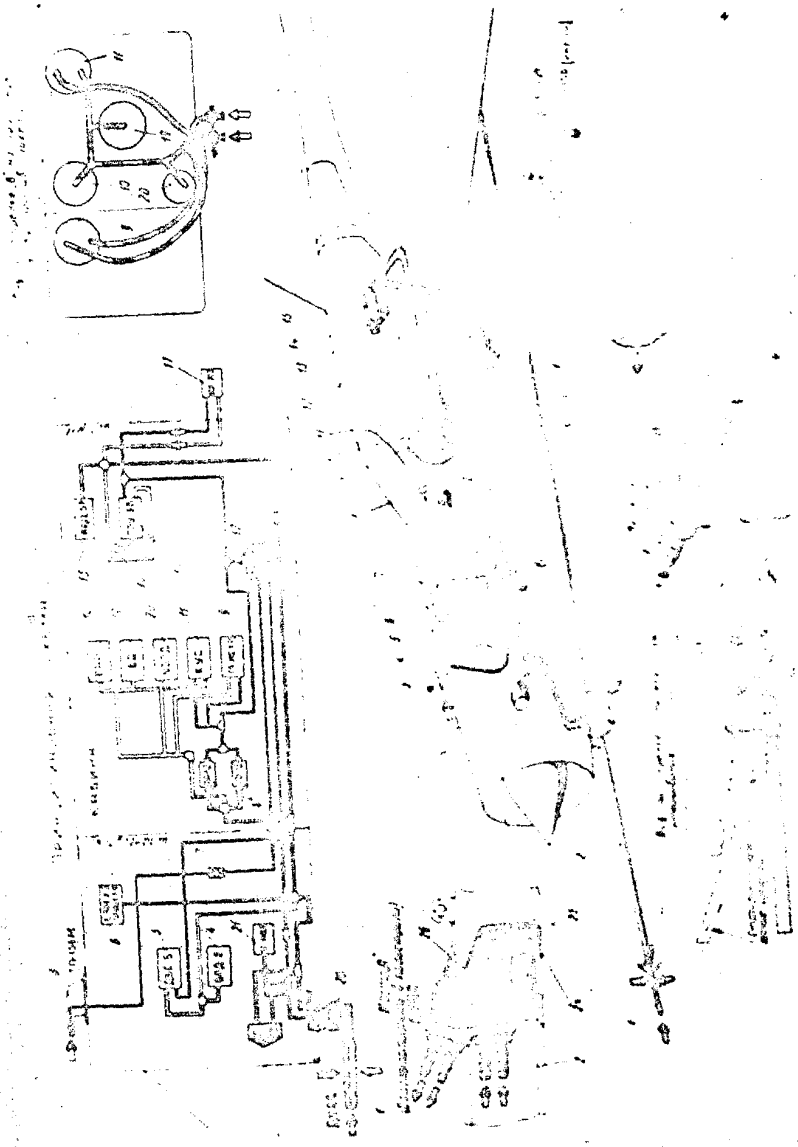

Figure 81. Aerovid-Diaphragm Instrument Supply System

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[redacted]

to the emergency receiver, TP-156M.

17. ARU-57 cockpit pressure regulator

18. Removable connection for ground checkin ARU-3V automatic device block

19. Resolver block of ARU-3V automatic device

27. KB-717 speed barograph

28. Instrument panel

29. Altimeter

30. CVFD

31. VS-14500 altitude signal

32. Breakable strut support

33. Securing screw

34. Sump plugs

35. Locking wire

36. Sump in DUAS-8M main line

[redacted]

The changeover from the DUAS-8M main receiver to the TP-156M emergency receiver in the dynamic pressure main line is accomplished by using the valve (12) installed on the port console in the cockpit.

There arespecial condensate traps in the piping system to protect the aneroid instruments from moisture which might get into them as a result of being brought into the system with the air flow. Two sumps (26) in the zone where the special spar is secured to the pylon, and one sump (7), installed in the nosewheel recess near frame number 5, are provided. The former is in the DUAS-8M main line, while the latter is in the TP-156M main line. Condensate should be drained off prior to flight.

[redacted]

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The DUAS-8M and TP-156M receivers are equipped with electric heaters. Circuit breakers, installed side by side on the instrument panel under the turn indicator, and marked "PVD, clocks," "Emergency PVD," "Heaters," are provided to cut in the electric heaters.

There is a removable connection (14) in the static pressure main supply line for ground checking the ARU-3V automatic device block. The connection is located near the block.

[illegible]4

5. Engine Control Instruments

Included in this group of instruments are the:

A. Remote electrical tachometer, ITE-2;

B. Exhaust gas thermometer, TVG-11T;

C. Fuel consumption guage, RTS16A-4;

D. Remote electrical lube oil guage, DIM-8T;

E. T-6 signal display.

All of the above mentioned instruments areconnected to transmitters by electrical connections.

A. Remote electrical tachometer, ITE-2

The ITE-2 (fig. 82) magnetic induction tachometer is designed to provide a continuous indication of the number of revolutions per minute being made by the rotors in the high and low pressure compressors in the jet engine, expressed in percentages of maximum rpm.

The ITE-2 complex consists of the ITE-2 meter and two DTE-1 transmitters, installed on the engine.

The ITE-2 meter has two needles and indicates low and high pressure compressor

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revolutions in the ranges from 0 to 105%, with each division equal to 1%.

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Figure 82. ITE-2 Tachometer

Figure 83. ITE-2 Electrical Schematic

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The DTE-1 induction transmitters feed the ITE-2 meter.

Figure 83 is the electrical schematic.

No.	No. of position in electrical schematic	Designation	Type	Quantity	Location
1	30K	Tachometer	ITE-2	1	Instrument panel
2	31K	Induction transmitter, low pressure rotor	DTE-1	1	Engine
3	32K	Induction transmitter, high pressure rotor	DTE-1	1	Engine

B. Exhaust gas thermometer, TVG-11T

The TVG-11T thermometer (fig. 84) measures the average temperature of the engine turbine exhaust gases. Included in the complex is a magneto-electrical millivoltmeter, TVG-1, and 4 T-1T thermocouples, connected in series.

The TVG-1 indicator scale is graduated from 300°C to 900°C, in 10°C steps. The operating range is from 450 to 750°C.

The thermoelectrical principle - the occurrence of an emf as a result of heating a junction of different alloys - is the operating principle of the TVG-11T thermometer.

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Figure 84. TVG-11T Thermometer

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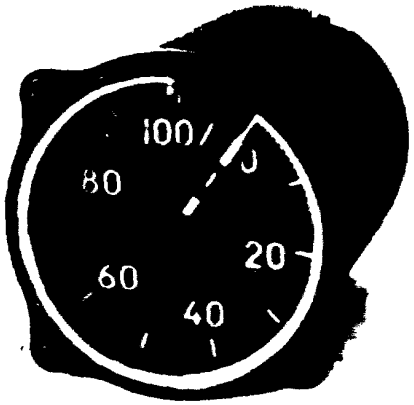

Fig. 82. ITE-2 Tachometer

[redacted]

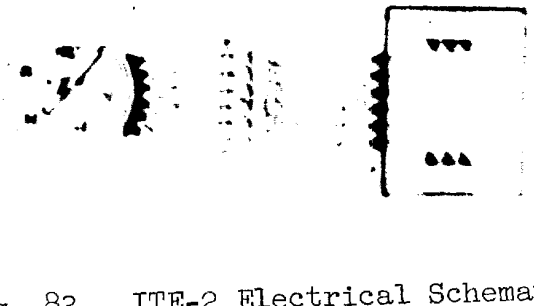

Fig. 83. ITE-2 Electrical Schematic

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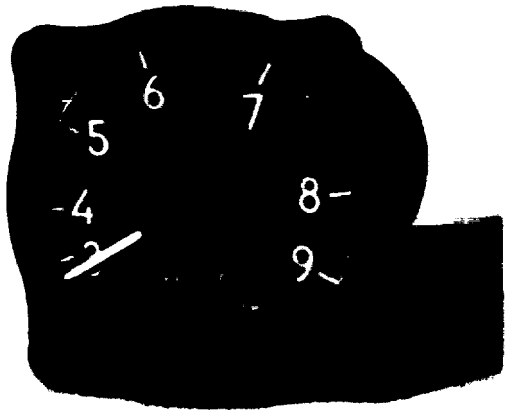

Фиг. 84. Термометр ТВГ-11Т.

Fig. 84. TVG-11T Thermoter

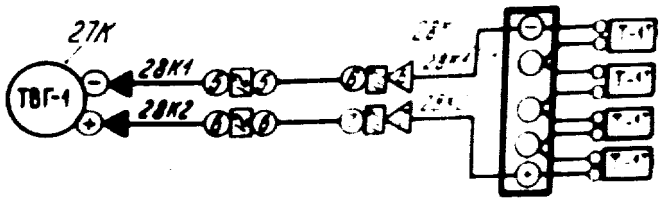

Fig. 85. TVG-11T Electrical Schematic

Фиг. 85. Электрическая схема ТВГ-11Т.

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Figure 85. TVG-11T Electrical Schematic

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Figure 85 is the electrical schematic for the meter.

No.	No. of position in electrical schematic	Designation	Type	Quantity	Location
1	27K	Indicator	TVG-1	1	Instrument panel
2	28K	Thermocouple block		1	In back fairing of fuselage, between frames 30 and 31
3	29K	Thermocouple	T-1T	4	Between frames 30 and 31

C. Fuel consumption guage, RTS 16A-4

The RTS 16A-4 cumulative fuel consumption guage (figure 86) measures the amount of fuel used by the engine. The fuel guage indicates the amount of fuel remaining in the tanks in horizontal flight with the fuel lines in good working order. The dial is graduated from 0 to 4000 liters with numbers every 1000 liters. Each division is 100 liters. At a temperature of +25±5°C the measurement error is not in excess of +2.5% of the value shown on the guage dial.

The fuel guage complex consists of the RTS16A-4 indicator, a transmitter, RTS16A, and a PT-56M thyratron cutout. Prior to a flight the fuel guage indicator

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Figure 86. RTS 16A-4 fuel guage

Figure 87. RTS 16A-4 electrical schematic

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needle must be set to the amount of fuel loaded. This is accomplished with the aid of a rack arrangment on the face of the guage.

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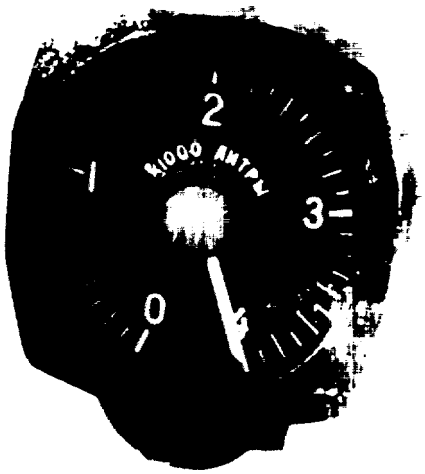

Fig. 86. RTS 16A-4 Fuel Guage

Фиг.86. Расходомер РТС16А-4.

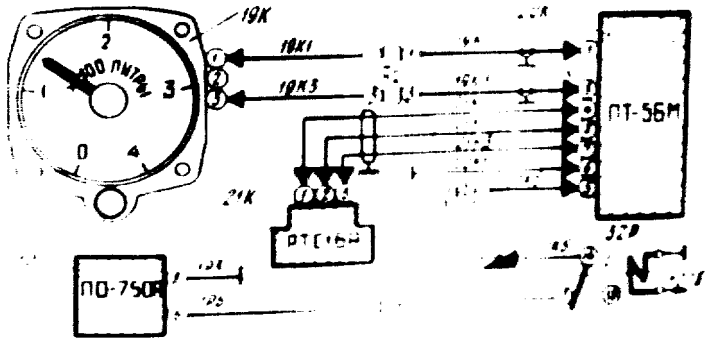

Fig. 87. RTS 16A-4 Electrical Schematic

Фиг.87. Электрическая схема РТС16А-4.

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The PO-750A converter supplies alternating current at 115 volts and 400 cycles, as shown in the electrical schematic in figure 87.

No.	No. of position in electrical schematic	Designation	Type	Quantity	Location
1	19K	Indicator	[illegible]16A-4	1	Instrument panel
2	20K	Thyratron cutout	PT-56M	1	Starboard side fuselage, between frames 12 and 13
3	21K	Transmitter	RTS16A	1	In port, lower section fuselage, between frames 20 and 22
4	1R	Converter	PO-750A	1	Lower nose section fuselage, frame no. 9
5	32R	Relay	TKYe-56PD	1	[illegible] box in battery compartment at frame no. 3
6	30	Fuse	SP-5	1	ditto

D. Lubricating Oil Pressure Guage for ERD

The remote electrical guage (fig. 88) measures the lubricating oil pressure in the engine. The scale ranges from 0 to 8 kilograms per square centimeter, in divisions of 0.5 kilograms per square centimeter. The indication error at a temperature of $+20\pm5^{\circ}C$ is about 3%.

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Figure 88. UI-1-8 Guage

Figure 89. Electrical schematic of guage supply

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The transmitter for the guage is the IDT-8. The DIM-8T complex consists of the UI-1-8 guage and the IDT-8T transmitter.

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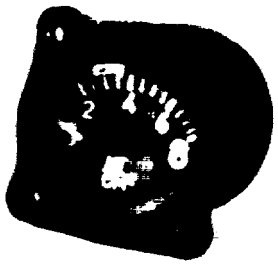

Фиг. 88. Манометр УИ-1-8

Fig. 88. UI-1-8 Guage

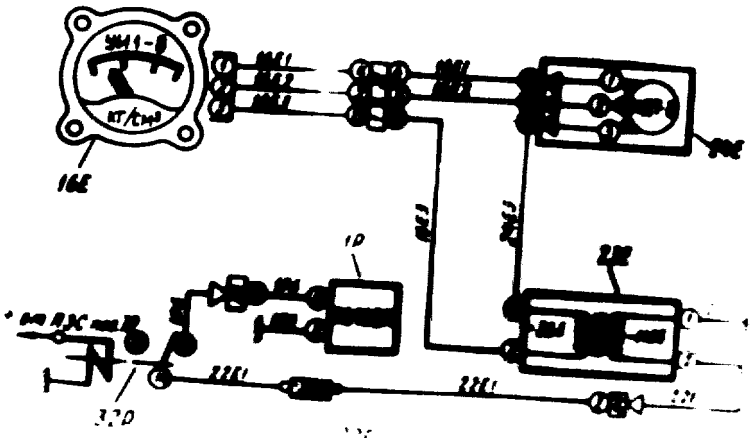

Fig. 89. Electrical Schematic of Guage Supply

Фиг. 89. Электрическая схема [illegible]

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The instruments are supplied with 36 volts, 400 cycle, AC from the PO-750A converter through a step-down transformer. The electrical schematic is shown in figure 89.

Alternating current at 115 volts and a frequency of 400 cycles is led from terminal 6 of the PO-750A converter (sym. 1R) through the normally closed contacts 13 and 14 of the relay (sym. 32R) and fuse 5A (sym. 22Ye) to the primary winding of the step-down transformer (sym. 23Ye). The current from the secondary winding, 36 volts, is supplied to the indicator (sym. 16Ye) and transmitter (sym. 24Ye).

No.	No. of position in electrical schematic	Designation	Type	Quantity	Location
1	16Ye	Indicator	UI-1-8	1	Instrument panel
2	22Ye	Fuse	SP-5	1	In relay box in storage battery recess near frame No. 9
3	23Ye	Transformer	115/36	1	
4	24Ye	Transmitter	IDT-8	1	
5	32R	Relay	TKYe-56PD	1	In storage battery recess near frame No. 9
6	1R	Converter	PO-750A	1	Under nose section of fuselage, frame No. 10

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D. Signal Display T-6

The T-6 signal display (fig. 90) provides light indications concerning:

engine operation with afterburner - the indicator light under a green light filter with the inscription "afterburner" lights up when the afterburner is cut in;

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a rise of temperature in the afterburner zone to above normal - the indicator light under the red light filter with the inscription "fire" lights up on receipt of a signal from the ionization transmitter IS-2M;

engine starting - an indicator light under a green light filter with the inscription "start engine" lights up when the start button is pressed and goes out when the engine has passed beyond the low gas mode;

generator operation - an indicator light under a red light filter with the inscription "generator in" will burn in the event the generator cuts out;

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Figure 90. Signal display T-6

improper operation of the fuel pump for the service tank - an indicator light under a red light filter with the inscription "service tank" will light up if service tank pump operation is not normal;

emergency fuel supply remaining - an indicator light under a red light filter with the inscription "500 liters remaining" will burn when 500 liters of fuel remain.

NOTE. The T-6 display installed in the aircraft is a specialized unit.

ATTENTION! In case of replacement the new display should have the same inscriptions and light filters as were installed on the display which was removed.

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6. Instruments for monitoring operation of individual aggregates

Instruments for use in monitoring individual aggregates in the aircraft include:

A. UVPD-20, indicator for altitude and pressure drop in cockpit;

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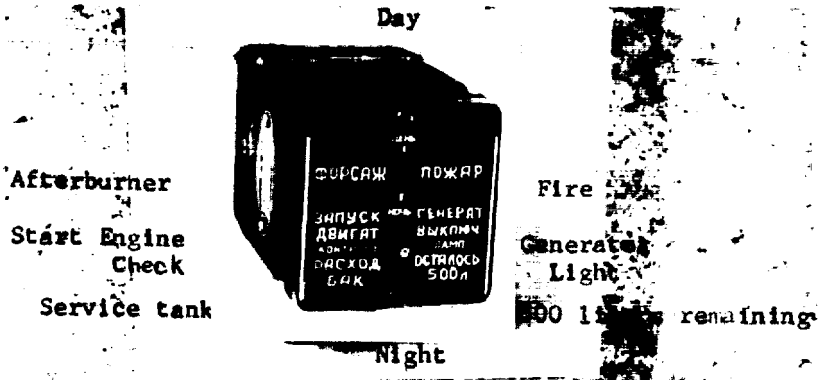

Figure 90. Signal display 1-6

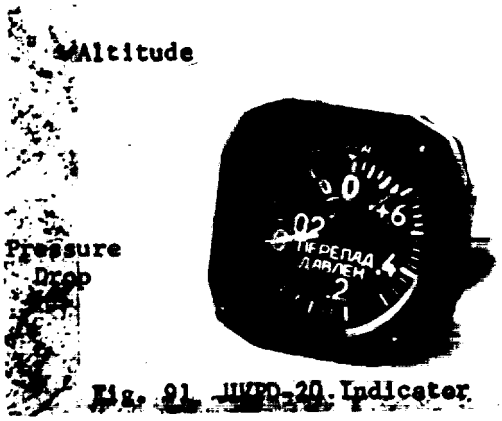

Fig. 91. UKPD-20 Indicator

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B. ISA, integrating counter for ampere-hours

C. 2EDM-250, electrical remote manometer;

D. 2M150, air manometer;

E. MV-12, manometer;

F. IK-18, oxygen indicator;

G. M-2000, manometer;

H. PPS-2, Flight - Landing Signal;

I. T-4, Signal display.

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UVPD-20

The indicator for altitude and pressure drop in the cockpit (figure 91) measures the "altitude" in the hermetically sealed cockpit and the drop (difference) between the pressure in the cockpit and the pressure in the atmosphere surrounding the aircraft.

The UVPD-20 is a combination instrument, containing an altimeter and a differential manometer in one casing. The two operate independently of each other. The altimeter shows the "altitude" in the sealed cockpit while static cockpit pressure works on the aneroid. If the cockpit becomes unsealed the altimeter shows the barometric altitude of the aircraft. The dial is calibrated in 0.5 kilometer divisions from 0 to 20 kilometers. Operation of the differential manometer is based on the measurement of the difference in pressure in the sealed cockpit and the surrounding medium, using an aneroid. The dial is calibrated in 0.02 kg/cm^2 divisions from -0.04 kg/cm^2 to +0.6 kg/cm^2.

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B. Integrating counter for ampere-hours

The ISA, the integrating counter for ampere-hours (fig. 92), is intended for operation in the aircraft's electrical equipment system and provides an

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indication of the available capacity of one of the storage batteries.

The complex includes the ISA counter itself, and an external shunt, ShIS. The external shunt, ShIS, is connected in series in the storage battery negative circuit.

Counter operation is based on the principle of a continuous addition of storage battery charging and discharging currents.

The initial value for capacity is set on the counter scale manually with a rack arrangement. Changes in capacity are computed in the counter by a continuous summing of the currents flowing through the shunt.

Figure 92 is the counter electrical schematic. Only two terminals, 1 and 2, are used in this particular aircraft. As will be seen from the schematic, the shunt voltage is fed to the motor "M" with permanent magnet by ways of terminals 1 and 2 of plug 2RM13KPN7Sh1A1. The motor will rotate in one direction or the other, depending upon whether the storage battery is being discharged or charged, and the needle moves to the corresponding position.

The motor moves the needle through the reduction gearing "R" and the transmission ratio is 1:14336.

That portion of the schematic indicated by the dashed lines is not used

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Figure 92. Integrating counter for ampere-hours
1 - Rack; 2 - needle; 3 - signal scale movable index; 4 - scale; 5 - Slot in scale

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in this particular type of aircraft.

When the storage batteries are installed in the aircraft the needle is set to the initial position for capacity value by pushing and turning the rack

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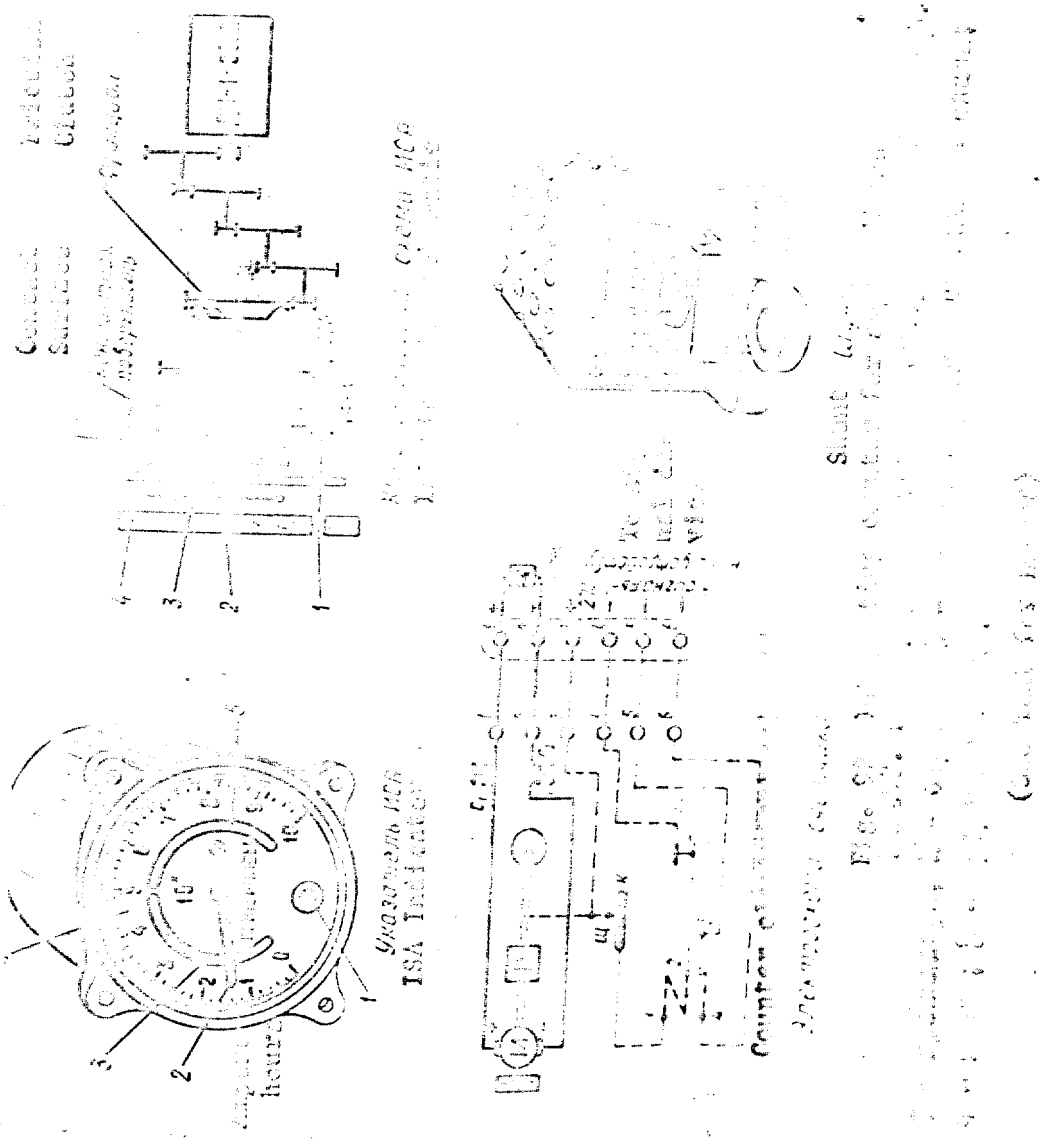

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(1).

Moving the needle on the counter by use of the rack during operation is prohibited until the batteries are replaced.

Technical Data

1. Capacity measurement range - 0 to 100 ampere-hours.

2. Counter sensitivity threshold - not more than 3 millivolts.

3. Counter operating range - from 3 to 1000 amps.

4. Counter error in operation during one cycle of charge-discharge:

(a) for ambient temperature 20±10°C - not more than 3%;

(b) over entire temperature range - not more than 5%.

5. Shunt resistance over entire temperature range and for any current not in excess of rated current - 0.001 ohm ±1%.

6. Shunt characteristics:

Conventional designation	Rated Current	Rated Voltage Drop	Permissible Overload Two Hours	Five Minutes	One Second
-	amperes	volts	amperes	amperes	amperes
ShIS	150	150	180	450	1000

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7. Operating temperature in surrounding medium:

(a) for counter - from +60°C to -60°C;

(b) for shunt - from +30°C to -60°C.

8. Counter withstands a maximum vibrational overload of 1.5 joules at a frequency of from 20 to 80 cycles per second.

9. Shunt withstands a maximum vibrational overload of 4.5 joules at frequencies from 20 to 200 cycles per second.

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10. Resistance of the pair of wires connecting the counter with the external shunt should not exceed 0.08 ohms.

11. Weight of shunt and counter 1.5 kilograms.

12. Life - 500 hours.

13. Counters and shunts of various of the complexes are mutually interchangeable.

Dismantling the counter during operation is prohibited.

If the counter fails to function correctly, it should be replaced by a new one.

[illegible] Hydraulic Manometer

The remote electrical manometer, 2EDM-250 (fig. 93) measures the hydraulic pressure in the booster and main hydraulic systems in the aircraft.

The complex includes two electrical transmitters, DV-250, which reproduce the pressure for the remote-reading, electrical indicator UI2-250. The indicator has two scales graduated from 0 to 250 kg/cm^2 in divisions of 10 kg/cm^2.

Figure 94 shows the electrical schematic.

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Figure 93. UK2-250 Indicator

Figure 94. Electrical schematic of the supply to the 2EDM-250

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+27 volts direct current from bus number 1 in the aircraft network is applied through the AZS-5 (sym. 13K) "EDM for the hydraulic system" on the electrical switchboard of the port console to the indicator (sym. 11K) and transmitters (sym. 12K, 17K).

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Fig. 93 UK2-250 Indicator

Equipment UK2-250.

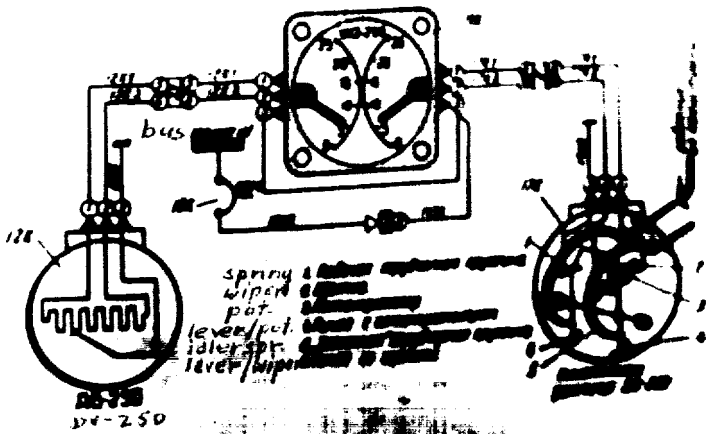

Fig. 94 Electrical schematic of the supply to the

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No.	No. of position in electrical schematic	Designation	Type	Quantity	Location
1	11K	Indicator	2EDM-250	1	Instrument panel
2	12K	Transmitter	DV-250	1	Between frames 21-22, to starboard, underneath
3	13K	Circuit breaker	AZS-5	1	Switchboard, port console
4	17K	Transmitter	DV-250	1	Frame number 20, to port

D. Air manometer 2M150

The twin air manometer 2M150 (fig. 95) indicates the air pressure in the main and emergency air systems. The scale is calibrated from 0 to 150 kg/cm^2 in 10 kg/cm^2 divisions.

E. Manometer MV-12

The air manometer MV-12 (fig. 96) indicates the control air pressure in the brake system for the main landing gear when the button on the brake lever on the stick is pressed.

The dial has two scales, graduated from 0 to 12 kg/cm^2, in 1 kg/cm^2 divisions.

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Figure 95. Manometer 2M150

Figure 96. Manometer MV-12

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F. Oxygen indicator IK-18

The oxygen indicator, IK-18, (fig. 97), indicates the pressure in the oxygen system and visually indicates delivery of oxygen to the mask or sealed helmet during breathing.

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Figure 95. Manometer 2M150

Figure 96. Manometer MV-12

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The instrument is a part of the aircraft oxygen system, KKO.

The instrument is both a manometer and an indicator, in one casing, each of which functions independently.

The upper part of the casing contains the manometer with the range of measurement between 0 and 150 kg/cm^2, indicating the oxygen pressure in the KKO system. Scale divisions are 10 kg/cm^2.

The lower part of the casing contains the indicator mechanism. When inhaling the leaves part and the supply port opens. On exhaling the leaves are returned to their original position by a spring. The leaves are synchronized during the inhaling and exhaling processes, periodically opening and closing. If the flow of oxygen is constant, the leaves are spread apart.

G. Manometer M-2000

The M-2000 manometer (fig. 98), in the KKO complex, measures the surplus oxygen pressure, in millimeter of a water column, in the mask at high altitudes.

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Figure 97. Indicator IK-18

Figure 98. Manometer M-2000

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The dial is calibrated from 0 to 2000 millimeters water, with each scale division equal to 100 millimeters of water.

H. Signal device PPS-2

The flight-landing signal, PPS-2 (sig. 99), provides a check on the landing gear, the flaps and the speed brakes, as well as to warn the pilot to lower his wheels on landing.

In the signal device, each of the two positions for the port, nose, and starboard legs of the landing gear is monitored on an individual signal.

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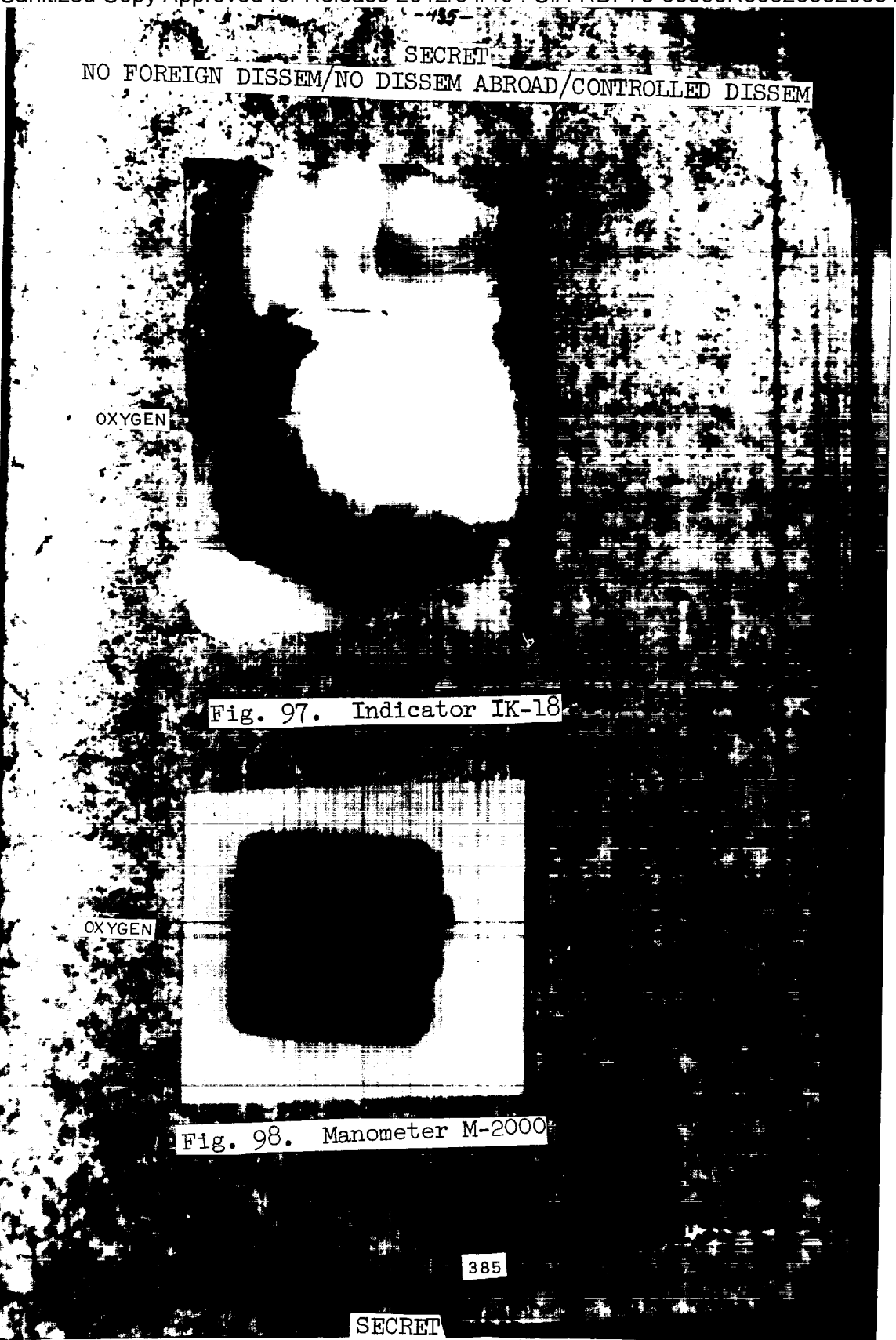

Fig. 97. Indicator IK-18

Fig. 98. Manometer M-2000

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Three red signals indicate that the landing gear is retracted, while three green ones indicate that the landing gear is down.

The signals which show the position of the flaps and the speed brakes, as well as the warning signals for lowering the landing gear, are in the form of lighted inscriptions "flaps down" and "brakes down" in green, while "landing gear down" is in red.

I. Display T-4

The T-4 display (fig. 100) has four [illegible] colored light filters with inscriptions: "[illegible] under a red one; "[illegible]ded," "landing stabilizer," and "trim effect [illegible]" under a green one. When the respective transmitters function the lights go on.

NOTE:

1. The T-4 display installed in the aircraft is a specialized unit.

ATTENTION: In event of replacement, the new display must have the same inscriptions and light filters as the display replaced.

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Figure 99. Signal device PPS-2

Figure 100. Display T-4

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CHAPTER IV

Oxygen Equipment

1. General information and purpose

In order to create the environment needed by the pilot, as well as to protect his ability to function, not only at high altitudes, but during ejection as well, the aircraft has installed the KKO-3 oxygen equipment complex with excess oxygen pressure in the hermetically sealed [illegible] and in the air

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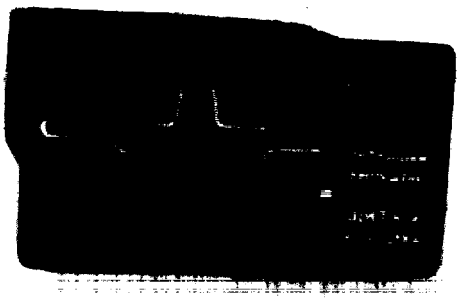

Fig. 99. Signal device PPS-2

Fig. 100. Display T-4

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stem of the altitude-compensated flight suit automatically adjusted according to the flight altitude.

The KKO-3 complex is designed to supply the pilot with oxygen under the following conditions:

(a) for long periods of time during flights in a sealed cockpit at altitudes up to the service ceiling and during flights in an unsealed cockpit to altitudes up to 12 kilometers;

(b) for short periods of time (up to 5 or 10 minutes) when the cockpit is not sealed at altitudes from 12 kilometers to the service ceiling when the complex is used as an emergency means for providing oxygen during the period of time required to descend to safe altitudes.

(c) for short periods of time while the pilot is being ejected from the aircraft at altitudes up to the service ceiling, with simultaneous and automatic transfer to the oxygen supply from the parachute device.

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The use of the compensating flight suit in the KKO-3 complex, with its anti-overload device, prevents inertial displacement of the blood from the head to the lower extremities, reducing the deleterious effect of overloads.

Included in the KKO-3 oxygen equipment complex are:

the on-board equipment, installed in the aircraft and remaining with it when the pilot leaves the plane;

the equipment which is part of the pilot's equipment and which is separated along with him when he leaves the plane.

The equipment in the aircraft includes:

the KP-34 oxygen gauge;

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remote control DU-2 for the KP-34 equipment

oxygen reducer KG-26;

guage valve KV-2MS;

oxygen indicator IK-18;

excess pressure guage M-8000;

complex of aircraft oxygen tubing [illegible];

communications connecting plug ORK-[illegible];

pressure reducing regulator RDS-3M (with connecting hoses);

spherical oxygen bottles, capacity 2 liters, pressure [illegible] kg/cm^2;

on-board oxygen apparatus (charging connections, detachable connections, T-joints);

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automatic pressure device AD-5A;

filter in the automatic pressure device AD-5.

The equipment which is part of the pilot's equipment includes the:

altitude compensating flight suit VKK-3M;

hermetically sealed helmet GSh-4M;

parachute oxygen device KP-27M.

In addition to the equipment listed, the aircraft is equipped with a complex of altitude equipment for communications which ensures two-way communications via radio.

The connection between the plane equipment and the pilot's outfit is made by the use of a communications connection plug ORK-2, installed on the port armrest on the seat.

When the pilot is catapulted (ejected) the ORK-2 plug is disconnected and

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The oxygen supply is switched automatically from the KP-34 to the KP-27M parachute outfit.

When the pilot leaves the cockpit without his parachute the equipment is disconnected from the plane's equipment by opening the bayonet-type locks on the inlet and outlet hoses to the pressure relation regulator [illegible] and the joints in the communication line and the window heater. When the pilot leaves the aircraft wearing his parachute the OKK-2 connections are broken by pressing the lock levers.

[illegible]

Figure [illegible] Oxygen equipment

[illegible]

The plane carries 8 liters of oxygen in four spherical tanks with a capacity of 2 liters each. Pressure in the tanks is [illegible] kg/cm^2.

The tanks are in two groups to extend the service life. Each group of tanks is equipped with a non-return valve, so that oxygen flows in but one direction - from the tanks to the KS-2MS valve. When either of the groups is out of service the non-return valve disconnects the particular group from the oxygen supply system and, at the same time, prevents oxygen leakage from the serviceable group of tanks.

All tanks are charged at the same time through a charging connection in the aircraft located in the port landing gear recess in the wing.

When the oxygen equipment is not in use the system can be shut off by the KV-2MS valve located in the cockpit, on the port console.

Operation of the oxygen system is control[illegible] with the aid of the IK-18 indicator and the M-2600 manometer, located on the instrument panel in the cockpit.

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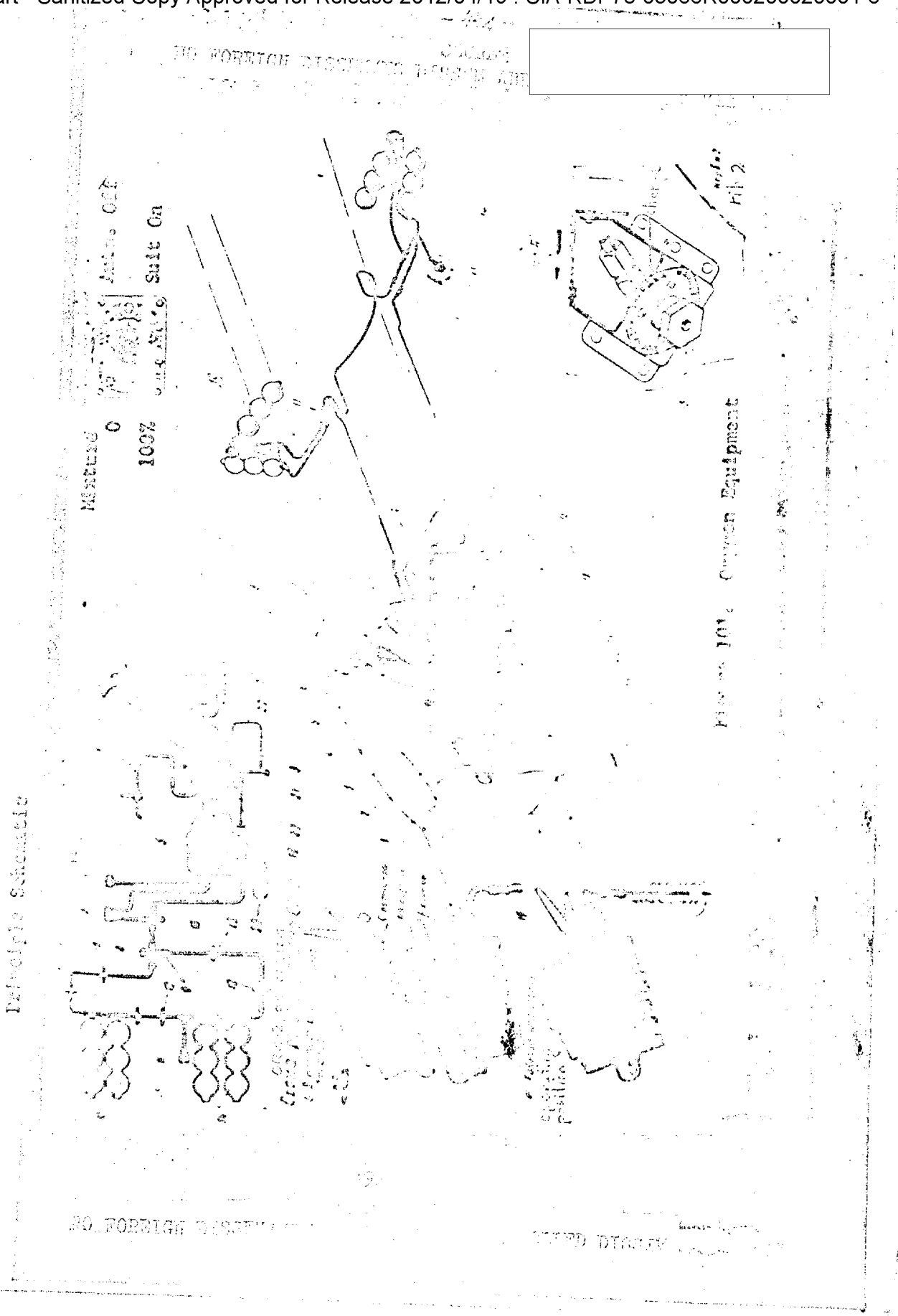

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Figure 101. Oxygen Equipment

1. [illegible] manometer
2. [illegible]-13 indicator
3. [illegible]-27M parachute equipment
4. [illegible]-3M pressure relation regulator
5. [illegible]-34 oxygen equipment
6. [illegible]-4M hermetically sealed [illegible]
7. [illegible] altitude compensating [illegible] unit
8. [illegible]-2MS equipment valve
9. Non-return valve
10. Spherical oxygen tanks
11. Detachable connection
12. Detachable connection
13. Coupling connection
14. Spherical oxygen tanks
15. Detachable connection
16. [illegible]-26 reducer
17. [illegible] automatic device filter
18. [illegible]A automatic pressure device
19. Interlocking cable
20. [illegible]-2 connection plug
21. [illegible]-27M manual connection
22. [illegible] quick-release clutch
23. [illegible]-2 remote control

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II. Aircraft Equipment

The KP-34 oxygen equipment delivers a mixture of oxygen and air to the hermetically sealed helmet worn by the pilot. It also activates the tensioning devices in the VKK altitude compensating flight suit.

The KP-34 oxygen equipment is of the lung-diaphragm type, with continuous oxygen flow.

The oxygen content in the mixture delivered is regulated automatically in accordance with the altitude. As the aircraft climbs the oxygen content in the mixture is increased.

Up to "cockpit" altitude of 12 kilometers the oxygen supply is provided by the lung-type automatic device in the KP-34 equipment. In order to eliminate the possibility of oxygen starvation should the helmet not be sealed, the KP-34 equipment maintains a slight excess pressure in the helmet, on the order of 30-40 millimeters water column, preventing the drawing in of air from the atmosphere.

At "cockpit" altitudes above 12 kilometers a continuous flow of oxygen is cut in, ensuring an absolute pressure in the lungs such as would be comparable to breathing pure oxygen at altitudes of 12-13 kilometers.

When the continuous oxygen flow is cut in the oxygen compartments in the compensating flight suit take 2.5 to 3 seconds to fill up. After this takes place the tensioning devices in the suit are activated and oxygen is then supplied for breathing purposes at a pressure of up to 1800 millimeters water col-

umn in the sealed helmet.

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A manually-operated, surplus pressure regulator is provided with the KP-34 equipment to check complex operation. This arrangement permits the establishment of a surplus pressure in the sealed helmet when on the ground.

The KP-34 oxygen equipment is located on the port console in the cockpit.

DU-2 remote control. The KP-34 oxygen equipment is fitted with a remote valve control, the DU-2, which permits remote control of the equipment from a special panel installed in the cockpit, on the horizontal section of the port console.

Remote control makes it possible to cut in, and cut out, the following units in the oxygen system:

the manual cut out for addition of air, which operates by a handle with the inscription "100% O_2 - Mixture;"

the manual mechanism for cutting in and cutting out continuous oxygen supply to the flight suit, which operates by a handle with the inscription "Cut in suit; N, cut out automatic device;"

the surplus oxygen manual regulator, which operates by a knob with the inscription "Close to limit."

KP-26 oxygen reducer. The reducer lowers the oxygen pressure delivered from the tanks from a pressure of 150 kg/cm^2 to from 7 to 14 kg/cm^2.

The reducer has a safety valve which releases oxygen in the event the pressure in the reducer chamber rises from 15 kg/cm^2 to 29 kg/cm^2.

The reducer is installed on the port side of the cockpit.

KA-2MS oxygen equipment valve. The valve acts as a cut off, separating the high pressure section of the equipment from the rest of the system. It

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is a stop-start valve of the diaphragm type for use with oxygen in gaseous form at pressures of up to 150 kg/cm^2.

The KV-2MS valve is installed on the port side of the cockpit.

IK-18 oxygen indicator. The indicator consists of two independent meters, installed in the same casing. One is the oxygen manometer, which indicates pressure in the oxygen tanks; the other is the oxygen indicator, for use in controlling operation of the KP-34 oxygen equipment.

M-2000 excess pressure manometer. The manometer controls the value of the excess pressure created by the KP-34 equipment in the GSh-4M sealed helmet. The scale is graduated from 0 to 20, with numbers every 2 divisions, and the scale divisions correspond to pressures from 0 to 2000 millimeters water column (the manometer readings must be multiplied by 100).

The M-2000 manometer is in the cockpit, on the amidships panel under the instrument panel.

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KSh-26 oxygen hose complex in the aircraft. The hoses connect the KP-34 oxygen equipment in the aircraft with the lower block of the ORK-2 connection plug on the port seat railing. The KSh-26 hose complex consists of three individual hoses with nipples and clamping nuts for connecting to the KP-34 equipment connections. The free ends of the hoses (those without nipples and nuts) are used to make the connections to the lower block of the plug.

The hoses are interconnected by rubber cups, to prevent their spreading out in various directions. As a result they lie in one vertical plane, parallel to each other.

In order to prevent mistakes when connecting the hoses to the KP-34 equip-

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[illegible] and to the ORK-2 plug, the threads of the hose clamping nuts are different. The hose which inflates the suit has a white index mark which corresponds with an index mark on the connection for the ORK-2 plug.

ORK-2 communications connection plug. The plug is designed to disconnect, automatically and simultaneously, all communications lines running from aircraft equipments and aggregates to the pilot equipped with [illegible] of KKO-3 oxygen equipment. This plug will [illegible] automatically cut in the KP-27M parachute oxygen equipment when the pilot is ejected from the aircraft.

[illegible] pressure-relation regulator. The regulator adjusts excess pressure in the sealed helmet and in the pneumatic system of the compensating flight

suit during the time the cockpit is being depressurized or during ejection.

A special lock secures the regulator to the tie-in system of the pilot's parachute.

Spherical oxygen tanks and aircraft mounting. The spherical tanks are installed in the starboard and port wing cantilevers, two tanks to a side, with each tank having a capacity of two liters. Oxygen working pressure is 150 kg/cm^2. The tanks have T-connections with non-return valves pressed in them. Each T-connection has two non-return valves, one for releasing oxygen, the other for admitting the oxygen. Use of non-return valves increases the service life of the oxygen system.

The aircraft mounting includes:

the aircraft charging connection;

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the detachable connections;

a T-connection;

the non-return valves;

the connections for coupling the piping to the equipment.

The aircraft charging connection is installed in the recess for the port landing gear in the wing cantilever. There is a non-return valve in the body of the aircraft connection which permits oxygen to flow into the system, but which prevents flow in the opposite direction. After the system is charged the aircraft connection is closed with a plug and sealing washer.

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The detachable connections make it possible to bring the piping into the cockpit, as well as to take the system apart when the wing cantilevers must be unjointed.

AD-5A automatic pressure device. The device is designed to fill the air chambers of the anti-overload apparatus in the VKK compensating flight suit, depending upon the overloads. The AD-5A device is not connected with the oxygen piping.

III. Pilot's Equipment

The VKK altitude compensating flight suit is designed to compensate for the excess pressure in the pilot's lungs, and to reduce the harmful effects of overloads.

The VKK altitude compensating flight suit consists of the following main parts:

the coverall;

the tensioning device;

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the anti-overload device.

The GSh-4M hermetically sealed helmet is an individual piece of equipment for the pilot and is an integral part of the KKO-3 oxygen equipment complex. In combination with the VKK suit the helmet provides the necessary conditions for pilot comfort at high altitudes.

[illegible]

Helmet electrical and radio apparatus. Included in the complex for the GSh-4M sealed helmet:

the complex of altitude apparatus for [illegible] communications by radio set;

sight panel with an electrically heated window, ensuring normal visibility within limits of ±50°C for fluctuations in ambient temperature when relative humidity is as high as 90%.

The complex of altitude apparatus for communications includes:

a DSHSh-1 (designation is blurred and may not be accurate) microphone which is of the electromagnet type, small in size and noise-resistant, installed in the telescopic adapter of the helmet;

two small-sized phones, TA-56M, installed in the helmet;

the lead-in wires to the phones and to the helmet.

To prevent moisture from condensing, or ice from forming, on the surface of the glass in the sight panel in the helmet, the latter is equipped with a heater made in the form of a wire-wound resistance which obtains its supply from the aircraft network.

The RKO-45 rheostat can be used to ensure [illegible] of the degree of heat for the window. The rheostat is found on the port console in the cockpit.

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The position of the rheostat knob will depend upon the temperature of the surrounding medium.

A button, located on the port console, and marked "fast heat for helmet" can be pushed if rapid heating of the sight glass is necessary to remove moisture or frost. Since, in this case, heating takes place with maximum power,

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the button should be held down for a short period of time only (not for longer than 2 or 3 minutes). When the button is released the electric heater will function in accordance with the position of the RKO-45 rheostat knob. If the rheostat fails in flight the window can be heated by periodically pressing the button indicated above.

The KP-27M parachute oxygen equipment is an equipment for individual use and has a continuous oxygen flow. This equipment supplies the pilot's need for oxygen during ejection or in the event the KP-34 installed equipment breaks down during flights at high altitudes (to descend to safe altitude).

Under normal flight conditions the oxygen, which is contained in a bank of tanks, is not expended and the pilot breathes oxygen, or a gas mixture, coming from the KP-34 equipment in the aircraft.

NOTE: More detailed information concerning the oxygen equipment units is provided in the descriptions and instructions compiled by the manufacturers of the KKO-3 oxygen equipment complex.

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CHAPTER V

Photographic Equipment

1. General Information

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A certain group of MiG-21F-13 aircraft have been selected for the installation of the AFA-39 aerial camera, which is a completely automatic camera with remote control from the command device and is designed for making aerial photographic reconnaissance in the daytime.

The camera can be used at altitudes from 500 to 5,000 meters (with possible use up to 10,000 meters) at flight speeds of up to 1,500 km/hour to obtain photography:

at scales of from 1:5000 to 1:50000 made by contact printing;

at scales of from 1:1000 to 1:10000 made by optical (or projection) printing.

The AFA-39 camera is installed in the root of the starboard wing cantilever behind the recess for the landing gear between ribs No. 1 and No. 2. The lens is enclosed in a special fairing with shutters.

The command device and the cutout switch for controlling the camera are installed in the cockpit on the middle panel, while the circuit breaker is on the forward electrical switchboard of the starboard console.

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2. Basic data for AFA-39

Lens	Uran 27
Lens focal length	10 centimeters
Lens speed	1:2.5
Field across picture diagonal	54°
Type shutter	Curtain
Shutter speed (effective)	1/700; 1/1400; 1/1800 sec.
Light filters	YeS-18; OS-14

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Picture size	7 x 8 cm
Number of pictures	200
Size of load of aerial film	8 x 1900 cm
Duration of cycle	not over 0.7 sec. for temperature from +15°C to + 25°C; 0.8 sec - for -60°C.
Current requirements for:	
temperature +20°C without heating	up to 5 amperes
temperature -60°C	up to 10 amperes
Voltage	27±10%

3. Complex composition

Included in the aerial camera complex are the:

A. aerial camera;

B. command device

C. cut out switch

D. electrical runs and plugs.

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4. Purpose of the aggregates in the AFA-39 aerial camera installation and location in the aircraft

The schematic showing the location of the camera equipment making up the AFA-39 installation is given in figure 102.

A. Aerial Camera

The aerial camera is designed to photograph objects which will be subjected to interpretation and study.

The camera is installed on the cover of the hatch in the root of the starboard wing cantilever, behind the landing gear recess, between ribs 1 and 2, and is secured by the ears of its shock mounts to the hatch bracket by four bolts. An

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opening, under the camera case, has been cut in the hatch cover. The cover is secured to the wing by four nuts.

The lens of the camera extends outside the wing enclosure and is protected from the action of the wind stream by fairing installed on the lower wing covering.

NOTE: Permissible displacement of the optical axis of the camera with respect to the hatch axis in the fairing is not more than 3 millimeters, while the permissible deflection relative to the aircraft axis, in all directions, not more than 3°.

The lens fairing consists of three sections, the former, middle and after, secured to the wing by screws and anchor nuts. The middle section is secured to the hatch cover and can be dismounted along with the hatch cover and the camera.

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Figure 102. Schematic of AFA-39 location in the aircraft

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Figure 102 Legend

1. R-165 plug (ShR-2)
2. KV-9A terminal switch for interlock
3. Aerial camera, AFA-39
4. ShRG2PN8EM3 plug
5. R-154 plug (ShR-7)
6. R-96 plug (ShR-7)
7. R-14 airtight plug (ShRG-7)
8. R-74 (ShR-25)

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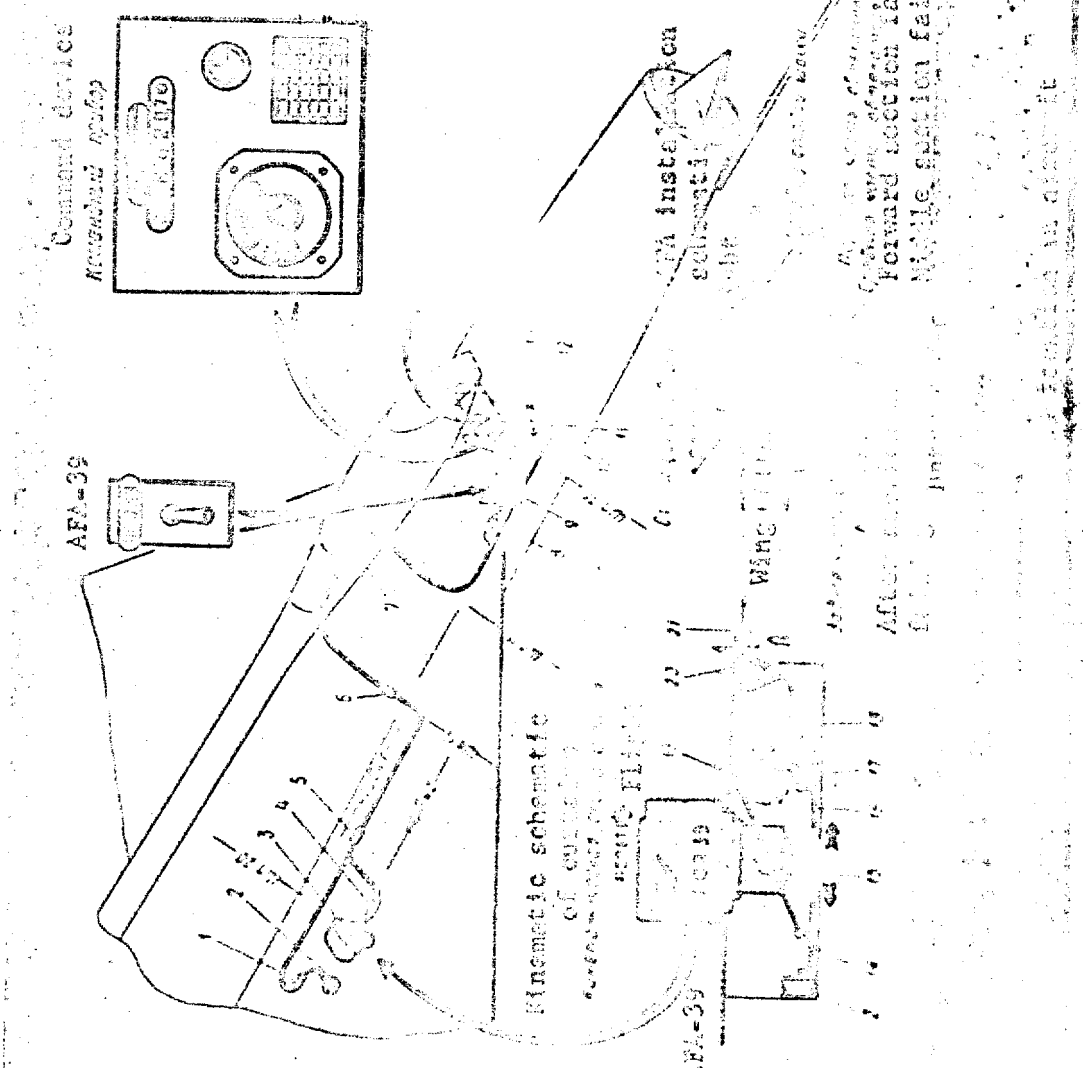

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9. AZS-10 circuit breaker
10. Amidships panel (instrument panel)
11. Command device
12. ShR32PK8EG3 plug
13. Cutout switch for operating AFA
14. After curtain
15. Pull rod (2 pieces)
16. Forward curtain
17. Return spring
18. Drive rod
19. Double-arm straight lever (2 pieces)
20. Double-arm angular lever
21. Stop on the panel of the landing gear strut

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There is, in the middle section of the fairing, a camera hatch (circular in shape) which permits the light image of the object to enter the camera lens. The camera hatch is closed by two curtains which move apart and which are operated by a control mechanism mounted in the forward and middle sections of the fairing and which is interlocked with retraction of the landing gear struts.

The landing gear strut flap, upon retracting, presses on the extended part of a double-arm lever while, at the same time, setting in motion the kinematics of opening the curtains.

Closing of the curtains when the landing gear is lowered results because of the tension on the return spring.

Installed in the after section of the fairing is the KV-9A terminal switch

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for interlocking operation of the camera installation with the curtains on the camera hatch. It eliminates the possiblity of exposing film when the camera hatch curtains are closed (or not fully open). Four bolts fasten the terminal switch to the fairing by the ears on the switch housing.

NOTE: When night flights are made the camera apparatus can be removed from the hatch and the lens fairing can also be removed. In their place there can be installed an extension-type landing light (in the same hatch).

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The command device for the AFA-39 is designed to control the camera remotely and to permit the automatic maintainance of intervals between pictures equal to 2, 4, 8, and 16 seconds, as well as to cut in the camera so it will operate continuously at intervals equal to the operating cycle for the camera (0.7 second). The command device permits monitoring film rewinding (a green pilot light burns) and (by a counter) the number of frames remaining in the camera.

The command device is installed on the middle section of the instrument panel and the casing is secured to two duralumin brackets by screws. Four screws and anchor nuts secure the brackets to the panel of the middle section.

C. Switch

Switch 87K, for operating the camera, is designed to shut off or to resume the process of photography by the camera.

The switch is installed on the middle section of the instrument panel, above the command device, and has a nameplate "AFA, On-Off."

The AZS-10 circuit breaker, with the nameplate "AFA-39" cuts in the supply to the AFA-39 electrical circuit using +27 volts. The supply comes from bus No. 4 of the aircraft network. The AZS is installed on the forward electrical switch-

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board of the starboard console in the cockpit.

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D. Mechanism for controlling the curtains on the camera hatch and for interlocking the functioning of the installation

Two curtains, a forward and after (fig. 102), are located in the middle section of the fairing and are flat plates which slide in grooves in two directions in channels secured to the fairing. When they are separated the curtains open the camera hatch. The curtain parts are connected with a mechanism for controlling the curtains and the kinematic scheme of it is shown in figure 102.

The control mechanism for the camera hatch curtains consists of a lever which connects with the curtains and is articulated, and two double-arm straight levers, along the common axis of which a return spring is installed. This spring closes the curtains and keeps them closed. The system is activated when the double-arm angular lever, installed in the forward section of the fairing, is pressed by the stop on the landing gear flap.

When the landing gear is retracted a special stop, installed on the flap for the starboard landing gear strut, acts on the arm of the angular lever and sets in motion the mechanism for controlling the curtains on the camera hatch. With rotation of the lever the rod for the forward section of the fairing, receiving forward motion (in the direction of flight), moves the forward curtain and the after curtain is moved through a system of levers and rods installed in the central section of the fairing. The curtains are separated and the camera lens hatch is opened.

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At the same time, the after curtain presses on the [illegible] of the interlocking

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terminal switch with its curved tail section.

When this process is completed aerial photographic reconnaissance can begin.

NOTE:

1.	Curtain travel, each curtain	not less than 50 millimeters
2.	Permissible overlap of open curtain over hatch opening	not more than 5 millimeters
3.	Displacement of the joint of the camera hatch curtains relative to the camera hatch rails must be not more than	2 millimeters

The electrical circuit ensures that the camera mechanism will be energized and will operate as required in flight.

Figure 103 is the principle electrical schematic and shows the camera supply circuits.

When the landing gear is retracted after take-off, the stop on the flap of the starboard landing gear strut acts on the angular lever in the fairing, thus opening the curtain on the camera hatch. The after curtain, moving, presses on the rod of the terminal switch interlock (sym. 6F), closing contacts 1 and 2, and readying the electrical circuit for operation.

The AZS-10 (sym. 3F) must be cut in prior to take-off. When switch 87K (sym. 4F) is cut in +27 volts from the aircraft network is supplied to the electric motor M in the command device through the closed contacts of the terminal switch KV-9A (sym. 6F).

The motor M begins to rotate the command device mechanism and, at the same time closes and opens contacts K periodically, at fixed intervals, sending pulses of current to the camera (sym. 1F). Each period is one cycle.

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27 volts is supplied from contacts K_1 to the camera at the winding of relay O_2, for dynamic braking. The relay functions and contact finger R_4 is drawn to the upper contact, thus delivering the supply to electric motor M_2.

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Figure 103. Electrical schematic for AFA-39 supply

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No.	No. of position in electrical schematic	Designation	Type	Quantity	Location
1	1F	Aerial camera	AFA-39	1	Starboard cantilever, ribs 1-2
2	2F	Command device		1	Cockpit, amidships panel
3	3F	Circuit breaker	AZS-10	1	Starboard console, forward switchboard
4	4F	Switch	87K	1	Cockpit, amidships panel
5	6F	Terminal switch	KV-9A	1	After section fairing for camera lens

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Motor M_2 starts turning the reduction and the main shaft of the camera mechanism, the shutter is cocked and released and the next frame is fed forward.

The current pulse passed by contacts K_2 is, timewise, shorter than the operating cycle for the camera, with the result that contacts K_2 are closed by a cam

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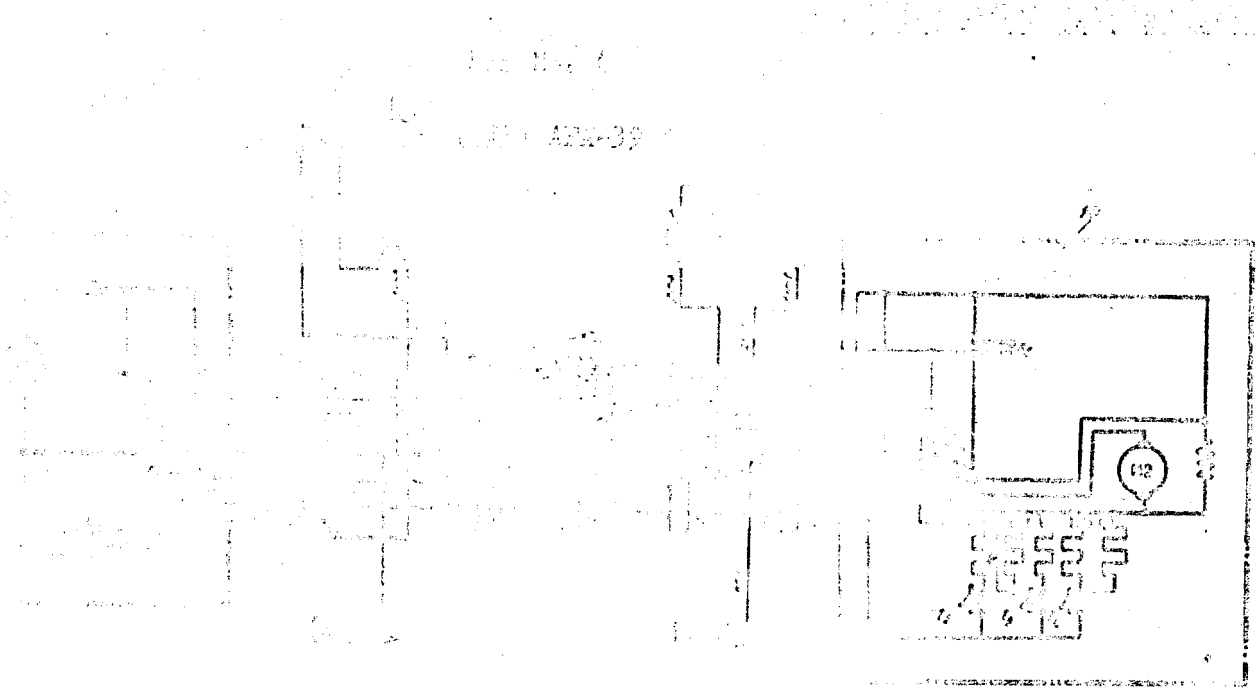
Figure 1[illegible]. Electrical schematic for AFA-39 supply



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on the main shaft in order to extend the cycle. After this, and until the end of the cycle, the supply to O_R relay winding comes through the closed contacts K_2. The motor continues to run.

Contacts K_3, which feed pulses to signal light L , close and open periodically, in the course of rewinding the film. The light burns at intervals, indicating normal rewinding of the film.

The film moves forward 1 frame for each revolution of the camera's main shaft.

At the end of the cycle contacts K_2 open, breaking the supply circuit to relay O_R. Contact finger K_3 closes the shorted winding in motor M_2, ensuring quick stoppage of the latter.

During the photographing process contacts K_1 close periodically and current pulses are supplied to the winding of the frame counter S_1 in the command device.

Each pulse is a cycle (one frame). The frame counter indicates the number of frames of film remaining.

Temperature regulators T_1, T_2, T_3 and T_4, which cut in automatically and maintain a constant temperature in the camera apparatus, are installed in the command device and in the camera to maintain constant temperatures for the operation of the AFA-39 equipment.

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